(19)日本国特許庁（ＪＰ）　(12)公開特許公報（Ａ）　(11)特許出願公開番号
特開2002－320228
（P2002－320228A）
(43)公開日　平成14年10月31日(2002.10.31)

(51)Int.Cl.⁷		識別記号	Ｆ Ｉ		テーマコード（参考）
Ｈ０４Ｎ	7/24		Ｈ０４Ｎ	7/13	Ｚ　５Ｃ０５３
	5/765			5/91	Ｌ　５Ｃ０５９
	5/91				Ｎ

審査請求　未請求　請求項の数21　ＯＬ　外国語出願　（全 37 頁）

(21)出願番号　特願2002－45209(P2002－45209)
(22)出願日　平成14年２月21日(2002.2.21)
(31)優先権主張番号　０１０４２９６．９
(32)優先日　平成13年２月21日(2001.2.21)
(33)優先権主張国　イギリス（ＧＢ）

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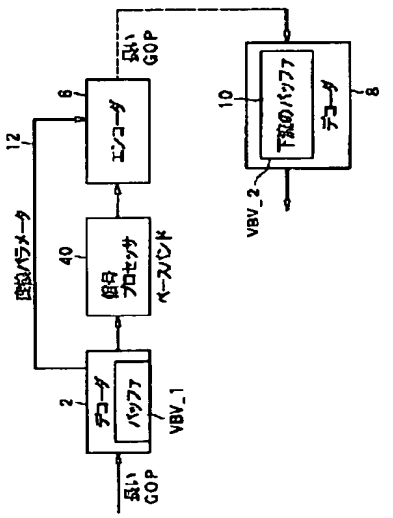
(54)【発明の名称】　信号処理装置

(57)【要約】　（修正有）
【課題】編集処理等で、圧縮ビットストリームを復号および再エンコードする際、画質を維持すると共に、バッファのアンダフローおよびオーバフローを回避する。
【解決手段】第１の圧縮デジタルビデオビットストリームを復号し、デコーダの第１のバッファ占有量Ｖ１を含む圧縮パラメータを保存するデコーダと、伸張ビットストリームを処理する信号プロセッサと、第１の圧縮デジタルビットストリームの圧縮パラメータを選択的に再利用し、下流のデコーダの第２のバッファ占有量Ｖ２を有する第２の圧縮ビットストリームを生成するエンコーダとを備え、エンコーダのターゲットビットレートは、Ｖ２およびＶ１とＶ２の差のいずれか一方又は両方に基づいて変更され、保存されたパラメータの再利用の度合いは、Ｖ２がアンダフローになる傾向の度合いおよびＶ１とＶ２との差が大きくなりアンダフローが生じる傾向の度合いのいずれか一方又は両方に基づいて変更される。



【特許請求の範囲】
【請求項１】　第１の圧縮デジタルビデオビットストリームを復号し、第１のビットストリームによるデコーダのバッファの占有量を表す第１のバッファ占有量V_1を含む該第１の圧縮デジタルビデオビットストリームの圧縮パラメータを保存するデコーダと、
伸張ビットストリームを処理する信号プロセッサと、
上記処理された伸張ビットストリームを圧縮し、上記第１の圧縮デジタルビットストリームの圧縮パラメータを選択的に再利用し、ターゲットビットレートを有し、第２のビットストリームによる下流のデコーダのバッファの占有量を表す第２のバッファ占有量V_2を有する第２の圧縮ビットストリームを生成するエンコーダとを備え、
上記エンコーダは、（ｉ）上記第２のビットストリームのターゲットビットレート及び（ｉｉ）上記第２のビットストリームの再符号化を制御して該ターゲットビットレートを達成し、
上記ターゲットビットレートは、（ａ）V_2及び（ｂ）V_1及びＶ２の差のいずれか一方又は両方に基づいて変更され、
上記保存された圧縮パラメータの再利用の度合いは、
（ａ）V_2がアンダフローになる傾向の度合い及び
（ｂ）V_1とV_2との差が大きくなりアンダフローが生じる傾向の度合いのいずれか一方又は両方に基づいて変更されることを特徴とする信号処理装置。
【請求項２】　上記V_2が下流のバッファのアンダフローに対応する所定の範囲内にある場合、上記第２のビットストリームは上記保存された圧縮パラメータを再利用することなくエンコードされ、これ以外の場合、上記第２のビットストリームは、上記保存された圧縮パラメータの少なくとも一部を再利用してエンコードされることを特徴とする請求項１記載の信号処理装置。
【請求項３】　上記V_2及びV_1の差が下流のバッファにアンダフローを生じさせる所定の閾値を超える場合、上記第２のビットストリームは、保存された圧縮パラメータを再利用することなくエンコードされ、これ以外の場合、上記第２のビットストリームは、上記保存された圧縮パラメータの少なくとも一部を再利用してエンコードされることを特徴とする請求項２記載の信号処理装置。
【請求項４】　上記圧縮ビットストリームは、イントラフレーム及び予測フレームのグループからなり、V_2が第１のV_2閾値Ｔｈ１より小さい場合、上記ターゲットビットレートは若干数減少され、上記保存された変換パラメータは、イントラフレーム及び少なくとも一部の予測フレームに対して再利用されることを特徴とする請求項３記載の信号処理装置。
【請求項５】　上記圧縮ビデオストリームは、イントラフレーム及び予測フレームのグループからなり、｜V_2－V_1｜が第１の（V_2－V_1）閾値より大きい場合、上記ターゲットビットレートは若干数減少され、上記保存された変換パラメータは、イントラフレーム及び少なくとも一部の予測フレームに対して再利用されることを特徴とする請求項３又は４記載の信号処理装置。
【請求項６】　上記フレームのグループは、Ｉフレーム、Ｐフレーム及びＢフレームを含み、Ｉフレーム及びＰフレームは、上記保存されたパラメータを再利用して再符号化され、Ｂフレームは、上記保存されたパラメータを再利用することなく再符号化されることを特徴とする請求項４又は５記載の信号処理装置。
【請求項７】　上記V_2が上記第１の閾値Ｔｈ１より小さい第２の閾値Ｔｈ２より小さい場合、上記ターゲットビットレートは、中程度数減少され、上記保存された変換パラメータは、イントラフレームのみに再利用され、予測フレームには再利用されないことを特徴とする請求項４乃至６いずれか１項記載の信号処理装置。
【請求項８】　｜V_2－V_1｜が第２の（V_2－V_1）閾値より大きく、第３の（V_2－V_1）閾値より小さい場合、上記ターゲットビットレートは、中程度数減少され、上記保存された変換パラメータは、イントラフレームのみに再利用され、予測フレームには再利用されないことを特徴とする請求項４乃至７いずれか１項記載の信号処理装置。
【請求項９】　上記V_2が上記第２の閾値Ｔｈ２より小さい第３の閾値Ｔｈ３より小さい場合、上記ターゲットビットレートは、大量数減少され、上記保存された変換パラメータは、いかなるフレームにも再利用されないことを特徴とする請求項４乃至８いずれか１項記載の信号処理装置。
【請求項１０】　｜V_2－V_1｜が上記第３の（V_2－V_1）閾値より大きい場合、上記ターゲットビットレートは、大量数減少され、上記保存された変換パラメータは、いかなるフレームにも再利用されないことを特徴とする請求項４乃至９いずれか１項記載の信号処理装置。
【請求項１１】　上記V_2が下流のバッファにおけるオーバフローの傾向を示し、及び／又はV_2のV_1からの差がオーバフローの傾向を示す場合、上記ビットストリームにスタッフィングビットを追加することを特徴とする請求項１乃至１０いずれか１項記載の信号処理装置。
【請求項１２】　第１の圧縮デジタルビデオビットストリームを復号し、第１のビットストリームによるデコーダのバッファの占有量を表す第１のバッファ占有量V_1を含む該第１の圧縮デジタルビデオビットストリームの圧縮パラメータを保存するデコーダと、
伸張ビットストリームを処理する信号プロセッサと、
上記処理された伸張ビットストリームを圧縮し、上記第１の圧縮デジタルビットストリームの圧縮パラメータを選択的に再利用し、ターゲットビットレートを有し、第２のビットストリームによる下流のデコーダのバッファの占有量を表す第２のバッファ占有量V_2を有する第２

の圧縮ビットストリームを生成するエンコーダとを備え、
上記エンコーダは、（ｉ）上記第２のビットストリームのターゲットビットレート及び（ｉｉ）上記第２のビットストリームの再符号化を制御して該ターゲットビットレートを達成し、
上記V_2が下流のバッファにおけるオーバフローの傾向を示し、及び／又はV_2のV_1からの差がオーバフローの傾向を示す場合、上記エンコーダは、上記ビットストリームにスタッフィングビットを追加し、上記保存されたパラメータを用いて上記第２のビットストリームを再符号化することを特徴とする信号処理装置。
【請求項１３】　上記V_2がバッファサイズの閾値以内又は（V_2－Ｖ１）がオーバフローを示すさらなる閾値レベルを超える場合、ビットストリームにスタッフィングビットを追加することを特徴とする請求項１２記載の信号処理装置。
【請求項１４】　上記信号プロセッサは、ビットストリームを記録する１以上の記録媒体と、上記デコーダからエンコーダにビットストリームを転送する通信チャンネルとを備えることを特徴とする請求項１乃至１３いずれか１項記載の信号処理装置。
【請求項１５】　上記信号プロセッサは、編集装置を備えることを特徴とする請求項１乃至１４いずれか１項記載の信号処理装置。
【請求項１６】　上記信号プロセッサは、イントラフレームのビットストリームを生成するイントラフレームエンコーダと、イントラフレーム信号プロセッサと、処理されたイントラフレームのビットストリームを復号し、上記処理された伸張ビットストリームを生成するデコーダとを備えることを特徴とする請求項１乃至１３いずれか１項記載の信号処理装置。
【請求項１７】　第１の圧縮デジタルビデオビットストリームを復号し、第１のビットストリームによるデコーダのバッファの占有量を表す第１のバッファ占有量V_1を含む該第１の圧縮デジタルビデオビットストリームの圧縮パラメータを保存するステップと、
伸張ビットストリームを処理するステップと、
上記処理された伸張ビットストリームを圧縮し、上記第１の圧縮デジタルビットストリームの圧縮パラメータを選択的に再利用し、ターゲットビットレートを有し、第２のビットストリームによる下流のデコーダのバッファの占有量を表す第２のバッファ占有量V_2を有する第２の圧縮ビットストリームを生成するステップとを有し、
エンコード処理において、（ｉ）上記第２のビットストリームのターゲットビットレート及び（ｉｉ）上記第２のビットストリームの再符号化を制御して該ターゲットビットレートを達成し、
上記ターゲットビットレートは、（ａ）V_2及び（ｂ）V_1及びＶ２の差のいずれか一方又は両方に基づいて変更され、
上記保存されたパラメータの再利用の度合いは、（ａ）V_2がアンダフローになる傾向の度合い及び（ｂ）V_1とV_2との差が大きくなりアンダフローが生じる傾向の度合いのいずれか一方又は両方に基づいて変更されることを特徴とする信号処理方法。
【請求項１８】　第１の圧縮デジタルビデオビットストリームを復号し、第１のビットストリームによるデコーダのバッファの占有量を表す第１のバッファ占有量V_1を含む該第１の圧縮デジタルビデオビットストリームの圧縮パラメータを保存するステップと、
伸張ビットストリームを処理するステップと、
上記処理された伸張ビットストリームを圧縮し、上記第１の圧縮デジタルビットストリームの圧縮パラメータを選択的に再利用し、ターゲットビットレートを有し、第２のビットストリームによる下流のデコーダのバッファの占有量を表す第２のバッファ占有量V_2を有する第２の圧縮ビットストリームを生成するステップとを有し、
エンコード処理において、（ｉ）上記第２のビットストリームのターゲットビットレート及び（ｉｉ）上記第２のビットストリームの再符号化を制御して該ターゲットビットレートを達成し、
上記V_2が下流のバッファにおけるオーバフローの傾向を示し、及び／又はV_2のV_1からの差がオーバフローの傾向を示す場合、上記エンコーダは、上記ビットストリームにスタッフィングビットを追加し、上記保存されたパラメータを用いて上記第２のビットストリームを再符号化することを特徴とする信号処理方法。
【請求項１９】　図１、図３及び図４を用いて説明し、図５及び図６を用いて任意に変更された、又は図２、図３及び図４を用いて説明し、図７及び図８を用いて任意に変更された信号処理装置。
【請求項２０】　図１、図３及び図４を用いて説明し、図５及び図６を用いて任意に変更された、又は図２、図３及び図４を用いて説明し、図７及び図８を用いて任意に変更された信号処理方法。
【請求項２１】　プログラミング可能な信号処理装置において実行され、請求項１７、１８及び／又は２０に記載の信号処理方法を実現するコンピュータプログラム製品。
【発明の詳細な説明】
【０００１】本発明は、信号処理装置、信号処理方法、及びこの信号処理方法を実現するコンピュータプログラム製品に関する。本発明の実施の形態は、圧縮ビデオビットストリームの処理に関する。本発明の好ましい実施の形態は、ＭＰＥＧ２規格に基づいて圧縮されたビデオビットストリームの処理に関する。
【０００２】本発明及びその背景をＭＰＥＧ２ビデオビットストリームを例に説明するが、本発明は、ＭＰＥＧ２ビデオビットストリームの処理に限定されるものでは

ない。

【０００３】ＭＰＥＧ２は、例えば、国際標準化機構（International Standardization Organization：ＩＳＯ）／国際電気技術委員会（International ElectrotechnicalCommission：ＩＥＣ）／１３８１８－２等により周知であり、ここでは詳細には説明しない。ＭＰＥＧ２圧縮ビデオは、グループオブピクチャ（Groups of Pictures）、すなわちＧＯＰとして知られているＩフレーム、Ｐフレーム及び／又はＢフレームのグループから構成される。Ｉフレーム、Ｐフレーム及びＢフレームについては、周知である。Ｉフレーム、すなわちイントラエンコードフレームは、他のいかなるフレームからも独立し、フレーム全体の情報を含んでいる。ＧＯＰ内のＰフレームは、最終的にはＩフレームに依存するが、他のＰフレームに依存してもよい。ＧＯＰ内のＢフレームは、最終的にはＩフレームに依存するが、ＧＯＰ内のＰフレームに依存していてもよい。Ｂフレームは、他のＢフレームに依存することはできない。

【０００４】ＧＯＰは、通常、少なくとも１つのＩフレームと複数のＰフレーム及び複数のＢフレームからなる１２個又は１５個のフレームから構成される。Ｂフレームを復号するために必要なビデオ情報の大部分は、ＧＯＰ内の先行及び／又は後続するフレームに含まれているため、ＧＯＰを正しく復号するためには、ＧＯＰ内の全てのフレームが必要である。同様に、Ｐフレームを復号するために必要なビデオ情報の大部分は、ＧＯＰ内の先行するフレームに含まれている。したがって、ＧＯＰは、少なくとも１つのＩフレームを含んでいる必要がある。さらに、ＧＯＰは、１つ以上のＰフレーム及び／又はＢフレームを有することができる。ＧＯＰは、例えばソニー株式会社のＳＸ装置のように、１つのＩフレーム及び１つのＢフレームのみから構成されていてもよい。

【０００５】圧縮ビデオデータに対し、編集やその他の処理を施す技術が知られている。周知の編集処理としてスプライシング処理（splicing）がある。アナログ信号の各フレームは、他のフレームから独立しており、そのフレームのビデオ情報全体を含んでいるため、アナログ信号のスプライシング処理は、比較的単純であり、隣接するフレーム間の境界において行うことができる。全てのフレームがそれぞれのフレームのビデオ情報全体を含んでいれば、圧縮されたビデオデータについても、圧縮されていないビデオデータについても、デジタル領域で同様のスプライシング処理を行うことができる。そこで、圧縮ビデオデータに対してスプライシング処理を施すために、Ｉ、Ｐ及び／又はＢフレームからなる元のＧＯＰを全てＩフレームに再エンコード（reencoding）し、これらのＩフレームに対してスプライシング処理を行い、さらに、これらのＩフレームを元のＧＯＰと同じ構造を有する新たなＧＯＰに再エンコードする手法が提案されている。他の処理も、Ｉフレームに対しては差し支えなく実行できる。元のＧＯＰを全てＩフレームに再エンコードするには、ＧＯＰをベースバンドに復号（decoding）し、Ｉフレームに再符号化（recoding）する必要がある。これに代えて、圧縮ビデオデータのＧＯＰをデジタルベースバンド（すなわち、非圧縮ビデオデータ）に復号し、ベースバンドビデオデータを処理し、Ｉフレームの再符号化の中間ステップを省略して、この処理されたビデオデータを圧縮ビットストリームとして再エンコードする手法も提案されている。

【０００６】復号処理及び再エンコード処理により、画質が劣化しやすい。そこで、ビデオデータを伸張する前に、圧縮ビデオデータの圧縮パラメータを保存し、ビデオデータを再エンコードする際、少なくとも処理により変更されていないフレームに対しては、この保存されたパラメータを再利用することにより、画質を維持する手法が知られている。例えば、元の圧縮ビデオデータのＩフレームは、元のビデオデータと同じ圧縮パラメータにより、Ｉフレームとして再エンコードされる。同様に、元のビデオデータのＰ及びＢフレームは、元の圧縮パラメータを用いて、Ｐ及びＢフレームとして再エンコードすることができる。このような処理の例は、欧州特許出願００３０６６９６．６号（代理人番号Ｉ－９９－２１、Ｓ００Ｐ５２０５ＥＰ００，Ｐ７３７４ＥＰ）に開示されている。

【０００７】圧縮ビデオビットストリームをＩフレーム又はベースバンドに復号した後、伝送及び／又は記録等、ビデオデータを変更しない単純な処理を施すとともに、復号されたデータを圧縮ビットストリームとして再エンコードすることもできる。

【０００８】ここで、圧縮ビットストリームをＩフレームに復号し、ビットストリームを再エンコードすることにより、復号されたビットストリームがビデオ情報を変更するか否かに関わらず、圧縮パラメータを再利用したとしても、再エンコードされたビットストリームのＧＯＰ毎のビット数と、元のビットストリームのＧＯＰ毎のビット数が変化することが見出された。また、圧縮ビットストリームをベースバンドに復号した後再エンコードする場合も同様な現象が生じる。これにより、下流のデコーダのバッファにおいて、アンダフロー又はオーバフローが起こることがある。

【０００９】そこで、圧縮ビデオビットストリームを復号及び再エンコードする際、画質を維持するとともに、バッファのアンダフロー及びオーバフローを回避することが望まれる。

【００１０】本発明の第１の形態である信号処理装置は、第１の圧縮デジタルビデオビットストリームを復号し、第１のビットストリームによるデコーダのバッファの占有量を表す第１のバッファ占有量V_1を含む第１の圧縮デジタルビデオビットストリームの圧縮パラメータを保存するデコーダと、伸張ビットストリームを処理す

る信号プロセッサと、処理された伸張ビットストリームを圧縮し、第１の圧縮デジタルビットストリームの圧縮パラメータを選択的に再利用し、ターゲットビットレートを有し、第２のビットストリームによる下流のデコーダのバッファの占有量を表す第２のバッファ占有量V_2を有する第２の圧縮ビットストリームを生成するエンコーダとを備え、エンコーダは、（ｉ）第２のビットストリームのターゲットビットレート及び（ｉｉ）第２のビットストリームの再符号化を制御してターゲットビットレートを達成し、ターゲットビットレートは、（ａ）V_2及び（ｂ）V_1及びＶ２の差のいずれか一方又は両方に基づいて変更され、保存されたパラメータの再利用の度合いは、（ａ）V_2がアンダフローになる傾向の度合い及び（ｂ）V_1とV_2との差が大きくなりアンダフローが生じる傾向の度合いのいずれか一方又は両方に基づいて変更される。

【００１１】本発明の第２の形態である信号処理方法は、第１の圧縮デジタルビデオビットストリームを復号し、第１のビットストリームによるデコーダのバッファの占有量を表す第１のバッファ占有量V_1を含む第１の圧縮デジタルビデオビットストリームの圧縮パラメータを保存するステップと、伸張ビットストリームを処理するステップと、処理された伸張ビットストリームを圧縮し、第１の圧縮デジタルビットストリームの圧縮パラメータを選択的に再利用し、ターゲットビットレートを有し、第２のビットストリームによる下流のデコーダのバッファの占有量を表す第２のバッファ占有量V_2を有する第２の圧縮ビットストリームを生成するステップとを有し、エンコード処理において、（ｉ）第２のビットストリームのターゲットビットレート及び（ｉｉ）第２のビットストリームの再符号化を制御してターゲットビットレートを達成し、ターゲットビットレートは、（ａ）V_2及び（ｂ）V_1及びＶ２の差のいずれか一方又は両方に基づいて変更され、保存されたパラメータの再利用の度合いは、（ａ）V_2がアンダフローになる傾向の度合い及び（ｂ）V_1とV_2との差が大きくなりアンダフローが生じる傾向の度合いのいずれか一方又は両方に基づいて変更される。

【００１２】本発明の第３の形態であるコンピュータプログラム製品は、適切なデータプロセッサ上で実行されて上述の信号処理方法を実現する。

【００１３】本発明により、保存したパラメータを再利用することにより、画質を維持しながら、アンダフローが生じる可能性が低い場合は、ビットレートを高く維持し、アンダフローが生じる可能性が高くなるにつれて、保存されたパラメータの再利用の度合いとビットレートを低減する。好ましくは、V_1及びV_2の値は、ビットレート制御することにより、これらの値が収束するように制御される。

【００１４】本発明の第４の形態である信号処理装置は、第１の圧縮デジタルビデオビットストリームを復号し、第１のビットストリームによるデコーダのバッファの占有量を表す第１のバッファ占有量V_1を含む第１の圧縮デジタルビデオビットストリームの圧縮パラメータを保存するデコーダと、伸張ビットストリームを処理する信号プロセッサと、処理された伸張ビットストリームを圧縮し、第１の圧縮デジタルビットストリームの圧縮パラメータを選択的に再利用し、ターゲットビットレートを有し、第２のビットストリームによる下流のデコーダのバッファの占有量を表す第２のバッファ占有量V_2を有する第２の圧縮ビットストリームを生成するエンコーダとを備え、エンコーダは、（ｉ）第２のビットストリームのターゲットビットレート及び（ｉｉ）第２のビットストリームの再符号化を制御してターゲットビットレートを達成し、V_2が下流のバッファにおけるオーバフローの傾向を示し、及び／又はV_2のV_1からの差がオーバフローの傾向を示す場合、エンコーダは、ビットストリームにスタッフィングビットを追加し、保存されたパラメータを用いて第２のビットストリームを再符号化する。

【００１５】本発明の第５の形態である信号処理方法は、第１の圧縮デジタルビデオビットストリームを復号し、第１のビットストリームによるデコーダのバッファの占有量を表す第１のバッファ占有量V_1を含む第１の圧縮デジタルビデオビットストリームの圧縮パラメータを保存するステップと、伸張ビットストリームを処理するステップと、処理された伸張ビットストリームを圧縮し、第１の圧縮デジタルビットストリームの圧縮パラメータを選択的に再利用し、ターゲットビットレートを有し、第２のビットストリームによる下流のデコーダのバッファの占有量を表す第２のバッファ占有量V_2を有する第２の圧縮ビットストリームを生成するステップとを有し、エンコード処理において、（ｉ）第２のビットストリームのターゲットビットレート及び（ｉｉ）第２のビットストリームの再符号化を制御してターゲットビットレートを達成し、V_2が下流のバッファにおけるオーバフローの傾向を示し、及び／又はV_2のV_1からの差がオーバフローの傾向を示す場合、エンコーダは、ビットストリームにスタッフィングビットを追加し、保存されたパラメータを用いて第２のビットストリームを再符号化することを特徴とする。

【００１６】本発明の第６の形態であるコンピュータプログラム製品は、適切なデータプロセッサ上で実行されて本発明の第５の形態である信号処理方法を実現する。

【００１７】本発明によれば、保存されたパラメータを再利用し、スタッフィングビットを追加することにより、画質を維持しながら、下流のバッファにおけるオーバフローを防止することができる。

【００１８】図１に示す装置は、ＭＰＥＧ２規格に基づいて圧縮されたデジタルビットストリームが供給される

デコーダ２を備える。ビットストリームは、例えばＩＢＢＰＢＢＰＢＢＰＢＢ等といったフレームの「長いＧＯＰ」を含んでいる。デコーダ２は、圧縮ビデオビットストリームをデジタルベースバンドに伸張する。Ｉ、Ｐ及びＢフレームの圧縮パラメータ（compression parameter）は、線１２で示すように、エンコーダ６に転送するために保存される。これらの圧縮パラメータは、全てのフレーム（すなわちＩ、Ｐ及びＢフレーム）について、以下の情報を含んでいる。

【００１９】フレームタイプの識別情報Ｉ、Ｐ、Ｂ
量子化スケール
ＤＣＴタイプ（フィールド又はフレーム）
量子化マトリクス（Quantiser matrix）

さらに、圧縮パラメータは、予測フレーム（すなわちＰ及びＢフレーム）については、以下の情報を含んでいる。

【００２０】予測タイプ（フィールド又はフレーム）
マクロブロックモード
動きベクトル

伸張されたベースバンドビデオビットストリームは、信号プロセッサ４０に供給される。信号プロセッサ４０は、特に、エンコーダ６に伸張ビデオデータを転送するための単なる通信チャンネルであってもよく、ベースバンドビデオデータを保存するための保存装置であってもよく、編集装置等の画像処理装置であってもよく、及び／又はデジタルベースバンド信号を処理するビデオ処理スタジオであってもよい。

【００２１】エンコーダ６は、ＭＰＥＧ２規格に基づいて、信号プロセッサ４０からのビデオデータを圧縮し、この具体例においては、好ましくは、デコーダ２に供給された長いＧＯＰと同様の長いＧＯＰを生成する。エンコーダ６は、保存された変換パラメータ（transcoding parameter）を用いて、処理されたビデオデータを圧縮し、バッファ１０を有する下流のデコーダ８にこの圧縮ビデオデータを供給する。

【００２２】図２に示す装置は、ＭＰＥＧ２規格に基づいて圧縮されたデジタルビットストリームが供給されるデコーダ２を備える。ビットストリームは、例えばＩＢＢＰＢＢＰＢＢＰＢＢ等といったフレームの「長いＧＯＰ」を含んでいる。デコーダ２は、圧縮ビデオビットストリームをデジタルベースバンドに伸張する。Ｉ、Ｐ及びＢフレームの圧縮パラメータは、線１２で示すように、エンコーダ６に転送するために保存される。これらの圧縮パラメータは、図１を用いて説明したパラメータと同様なものである。

【００２３】伸張されたベースバンドビデオデータは、イントラフレームエンコーダ（intra-frame encoder）１４に供給され、イントラフレームエンコーダ１４は、ベースバンドビデオデータをＩフレームに圧縮する。イントラフレームエンコーダ１４は、再エンコードされるビットストリームの制約が許す限り、元のＩフレームの保存された圧縮パラメータを用いて、各フレームをＩフレームとして再符号化する。このＩフレームは、信号プロセッサ４１に供給される。信号プロセッサ４１は、特に、エンコーダ６に伸張ビデオデータを転送するための単なる通信チャンネルであってもよく、ベースバンドビデオデータを保存するための保存装置であってもよく、編集装置等の画像処理装置であってもよく、及び／又はイントラフレーム情報を処理するビデオ処理スタジオであってもよい。

【００２４】処理されたＩフレームは、デコーダ１６に供給され、デコーダ１６は、これら処理されたＩフレームをベースバンドに復号するとともに、線１８で示すように、Ｉフレームの圧縮パラメータを保存し、ベースバンドビデオデータをエンコーダ６に供給する。

【００２５】エンコーダ６は、ＭＰＥＧ２規格に基づいて、デコーダ１６からのビデオデータを圧縮し、この具体例においては、好ましくは、デコーダ２に供給された長いＧＯＰと同様の長いＧＯＰを生成する。エンコーダ６は、保存された変換パラメータを用いて、処理されたビデオデータを圧縮し、バッファ１０を有する下流のデコーダ８にこの圧縮ビデオデータを供給する。

【００２６】図１及び図２に示すデコーダ２は、バッファを備え、その占有量（occupancy）をVBV_1とする。VBV_1は、デコーダ２において、それを測定することにより、分かる。下流のデコーダ８は、バッファを備え、その占有量をVBV_2とする。VBV_2は、エンコーダ６において推定される。

【００２７】図１及び図２に示す装置のいずれにおいても、信号プロセッサ４０、４１がビデオデータを全く変更せずに伝送すると仮定すると、エンコーダ６において、圧縮パラメータを再利用して、デコーダ２に供給された長いＧＯＰを再構築する場合、VBV_1は、VBV_2と同じになる。しかしながら、実際には、VBV_2とVBV_1は異なり、VBV_2は、VBV_1から次第に乖離していく（drift apart）ことが見出された。この要因としては、様々なものが考えられる。まず、デコーダ２における逆ＤＣＴ変換及びエンコーダ６におけるＤＣＴ変換時の丸め誤差が要因の１つである。さらに、図２に示す装置においては、元のビットストリームを復号し、ビットストリームを再エンコードすることにより、例えば、元はＩフレームであったフレームがＰフレームになる、又はその逆等、フレームタイプが変更されてしまうことも要因の１つである。このような場合、量子化スケールが変化する。このような誤差は、図１に示す装置よりも図２に示す装置において生じやすい。図３及び図４は、VBV_1とVBV_2の乖離を示す図である。このような乖離を制御しないと、下流のバッファ１０において、アンダフロー又はオーバフローが生じることがある。

【００２８】本発明の好ましい実施の形態においては、

この乖離を制御する。図３及び図４について説明する。VBV_2は、図１及び図２に示す下流のバッファ１０の占有量である。VBV_1は、上流のデコーダ２のバッファの占有量である。Buffer_sizeは、下流のバッファ１０のバッファ容量である。閾値VBV_Thresh1、VBV_Thresh2及びVBV_Thresh3は、設定により決定される。これらの閾値は、全て、Buffer_sizeのパーセンテージとして設定される。閾値の具体例を以下に示す。

【００２９】VBV_Thresh1をBuffer_sizeの２０％とする
VBV_Thresh2をBuffer_sizeの１５％とする
VBV_Thresh3をBuffer_sizeの１０％とする
図３及び図４に示す太線は、上流のデコーダ２に供給される元の圧縮ビットストリームのＧＯＰを示し、細線は、エンコーダ６により生成される対応した再符号化ビットストリームのＧＯＰを示す。これらのＧＯＰは、図３及び図４に示す具体例では、例えばＩＢＢＰＢＢＰＢＢＰＢＢＰＢＢの１５フレームのシーケンスを有する長いＧＯＰである。元のビットストリームにおける各Ｉ、Ｂ、Ｐフレームは、エンコーダ６により、それぞれ同じタイプのＩ、Ｐ、Ｂフレームに再符号化されている。

【００３０】ここで、値VBV_driftを算出する。VBV_driftは、エンコーダ６により生成される再符号化ビットストリームのフレームによる下流のバッファ１０の占有量と、元のビットストリームにおける対応するフレームによる上流のバッファの占有量との間の差分（VBV_2－VBV_1）である。VBV_2も求められる。VBV_2及びVBV_driftは、この具体例においては、ＧＯＰにおけるＩフレームにおいて、ＧＯＰ毎に１回ずつ求められる。これに代えて、これらの値をＧＯＰの各フレームにおいて求めてもよく、例えば、Ｂフレームを除いて、Ｉフレーム及びＰフレーム等、全てのフレームではないが複数のフレームにおいて求めてもよい。Ｉフレームは、（必ずしもそうでない場合もあるが）バッファの占有量が最も大きく、占有量の変化に最も大きな影響をもたらすものであるため、少なくともＩフレームにおいて、ＧＯＰ毎にこれらの値を求めることが望ましい。なお、他の具体例においては、VBV_2及びVBV_driftは、１つおきのＧＯＰ毎に求めてもよく、この他の適切な間隔で求めてもよい。

【００３１】オーバフロー及び正のＶＢＶ乖離
図３は、オーバフローの傾向を有するVBV_2のVBV_1からの乖離を示しており、VBV_1とVBV_2の乖離は、各ＧＯＰの開始時におけるＩフレームにおいて、ＧＯＰ毎に１回求められる。

【００３２】ここで、（VBV_2＞Buffer_size－VBV_Thresh1）又は（VBV_drift＞VBV_Thresh3）の場合、エンコーダ６において、Ｉフレームの後にスタッフィングビット（stuffing bits）がＧＯＰに追加され、VBV_2を減少させる。オーバフローの傾向がある場合、エンコーダ６は、保存されている変換パラメータを全て用いてＧＯＰを生成する。例えば、VBV_2は、下流のバッファ１０の占有量である。下流のバッファ１０の占有量は、エンコーダ６のバッファの占有量に反比例する。エンコーダ６において、ビットを追加して占有量を増加させると、下流のバッファ１０における占有量が減少する。

【００３３】図３には、閾値Buffer_size－VBV_Thresh1が示されている。VBV_2が閾値を超えると、下流のバッファは、オーバーフローしやすい。

【００３４】さらに、図３には、VBV_drift及びVBV_Thresh3の比較も示されている。VBV_driftがVBV_1から大きく離れている場合も下流のバッファにオーバフローが生じやすい。また、VBV_driftは、VBV_1とVBV_2との差が大きくならないように監視される。ＧＯＰに追加されるスタッフィングビットの数は、VBV_2が減少してVBV_1に近づくように、及び将来アンダフローが発生する可能性を低減するために、VBV_1より大きな値となるように選択される。スタッフィングビットは、好ましくは、VBV_2の値がより小い方であって、VBV_2が（Buffer_size－VBV_Thresh1）又は（VBV_1＋VBV_Thresh3）の何れかに等しくなるまで追加される。

【００３５】アンダフロー及び負のＶＢＶ乖離
図４は、アンダフローの傾向を有するVBV_2のVBV_1からの乖離を示しており、上述の具体例と同様に、VBV_1とVBV_2の乖離は、各ＧＯＰの開始時におけるＩフレームにおいて、ＧＯＰ毎に１回求められる。さらに、ここでは、値Iframe_Offsetも使用している。この値は、典型的なＩフレームのサイズを表す予め定められた固定値としてもよい。これに代えて、この値は、Ｉフレームのサイズを測定することにより、各Ｉフレーム毎に決定してもよい。Iframe_Offsetにより、ＧＯＰの開始時において、Ｉフレームを復号する際、下流のバッファからビットを取り除くことができる。

【００３６】アンダフローが生じる可能性及び負のＶＢＶ乖離を低減するために、各ＧＯＰの開始時にＧＯＰ毎のターゲットビット数を減少させ、乖離が大きくなり、及びアンダフローが生じる可能性が高くなるように、保存されている変換パラメータの使用の割合を低下させる。すなわち、アンダフローが生じる可能性を低下させるために、ＧＯＰ毎のターゲットビット数を減少させる。例えば、下流のバッファ１０の占有量をVBV_2とする。下流のバッファ１０の占有量は、エンコーダ６のバッファの占有量に反比例する。エンコーダ６において、ターゲットビット数を減少させると、下流のバッファ１０における占有量が増加する。

【００３７】この具体例においては、（VBV_2＜VBV_Thresh1＋Iframe_Offset）又は（VBV_drift＜マイナスVBV_Thresh3）の場合、ＧＯＰのターゲットビット数を若干数減少し、Ｉ及びＰフレームについては保存されている変換パラメータを再利用し、Ｂフレームは、保存されている変換パラメータを再使用することなく再符号化する。これらの基準は、アンダフローの要因となり得る小

さなＶＢＶ乖離を示している。上述した若干数とは、例えば、VBV_driftの値、又はこの値に正比例する値とする。

【００３８】また、（VBV_2<VBV_Thresh2+Iframe_Offset）又は（VBV_drift<マイナスVBV_Thresh2）の場合、ＧＯＰのターゲットビット数を中程度数減少し、Ｉフレームについては保存されている変換パラメータを再利用し、Ｂ及びＰフレームは、保存されている変換パラメータを再使用することなく再符号化する。これらの基準は、アンダフローの要因となる中程度のＶＢＶ乖離を示している。上述した、中程度数とは、例えば、VBV_driftの値、又はこの値に正比例する値とする。

【００３９】また、（VBV_2<VBV_Thresh3+Iframe_Offset）又は（VBV_drift<マイナスVBV_Thresh1）の場合、ＧＯＰのターゲットビット数を大量数減少し、保存されている変換パラメータは、全く使用せず、Ｉ、Ｐ及びＢフレームは、全て保存されている変換パラメータを再使用することなく再符号化する。これらの基準は、アンダフローの要因となる大幅なＶＢＶ乖離を示している。上述した大量数とは、例えば、VBV_driftの値、又はこの値に正比例する値とする。

【００４０】ターゲットビット数（したがってビットレート）を変化させる量は、ビットレートの変化量が許容可能な範囲内に確実に収まるように選択される。

【００４１】上述の基準は、いずれも（VBV_2<VBV_ThreshX+Iframe_Offset）又は（VBV_drift<マイナスVBV_ThreshY）の２つの条件を有する。ターゲットビット数をどれ程減少させるか、及び変換パラメータをどの程度再利用するかは、好ましくは、これら２つの条件のうち悪い（より大きなＶＢＶ乖離を示す）方に基づいて決定する。

【００４２】これにより、変換パラメータを可能な限り再利用して、画質を可能な限り維持することができる。

【００４３】なお、VBV_drift<マイナスVBV_ThreshYは、VBV_driftが負の値であるVBV_ThreshYより大きな負の値を有することを示している。絶対値として表現すれば、｜VBV_drift｜＞｜VBV_ThreshY｜である。

【００４４】図５及び図６に示す具体例

図５は、本発明を適用したスプライシング装置の構成を示す図である。このスプライシング装置の入力端子Ａ、Ｂには、長いＧＯＰの圧縮ビットストリームであるビットストリームＡ及びビットストリームＢが入力される。ビットストリームＢは、ベースバンドに復号され、切換スイッチＳ１として示されるスプライサにより、スプライス点Spliceにおいて、復号されたビットストリームＡにスプライスされ、これにより、スプライスされたベースバンドビットストリームＣが生成され、エンコーダ６は、このベースバンドビットストリームＣを再エンコードする。エンコーダ６は、コントローラ６１により制御される。コントローラ６１には、復号されたビットストリームから保存された変換パラメータが供給されている。

【００４５】図６に示すように、時刻ｔ０より前に、ビットストリームＡ０は、デコーダ２１の入力端子側から、遅延器ＤＡを介して、切換スイッチＳ２の入力端子Ａに供給され、これによりこのスプライシング装置の出力端子Ｓ０から出力される。時刻ｔ１からスプライス時刻ｔ２以前の期間、デコーダ２１がビットストリームＡ０をベースバンドに復号し、スプライサＳ１の入力端子Ａに供給する。一方、デコーダ２２は、ビットストリームＢ０をベースバンドに復号し、スプライサＳ１の入力端子Ｂに供給する。時刻ｔ２以前は、スプライサＳ１は、入力端子Ａに供給された信号を出力端子Ｃから出力する。また、スプライサＳ１は、時刻ｔ２以降は、入力端子Ｂに供給された信号を出力端子Ｃから出力する。エンコーダ６は、遷移期間である時刻ｔ１から時刻ｔ３の間、スプライスされたビットストリームを保存されている変換パラメータを使用せず、又は一部のみを使用して再エンコードする。この期間においては、ビットストリームＡのＶＢＶ値からビットストリームＢのＶＢＶ値への遷移が制御されるように再エンコードが行われる。好ましくは、保存されているＩフレームパラメータを用いて、元々Ｉフレームであったフレームを Ｉフレームとして再符号化する。この再符号化の手法は、同時に継続中の欧州特許出願００３０６６９９．０号（代理人番号Ｉ－９９－１９、Ｓ００Ｐ５１３０、Ｐ／７３７２）に開示されており、この出願は、参照により本願に組み込まれるものとする。時刻ｔ３においては、ビットストリームＣのＶＢＶは、ビットストリームＢのＶＢＶに一致する。時刻ｔ３から時刻ｔ４の間は、ビットストリームＢの再符号化が継続される。時刻ｔ４においては、切換スイッチＳ２は、入力端子Ｃを入力端子Ｂに切り換え、これにより、このスプライシング装置の出力端子Ｓ０からは、圧縮ビットストリームＢ０が出力される。時刻ｔ３から時刻ｔ４までの期間においては、エンコーダ６は、本発明に基づき、図１、図３及び図４を用いて説明したように動作し、これにより、時刻ｔ４において、ＶＢＶ値が可能な限り近似するように、エンコーダ６により生成されるビットストリームＶＢＶ値の元のビットストリームＢ０からの乖離が低減される。

【００４６】図７及び図８に示す具体例

図７は、本発明を適用したスプライシング装置の構成を示すブロック図である。このスプライシング装置の入力端子Ａ、Ｂには、長いＧＯＰの圧縮ビットストリームであるビットストリームＡ及びビットストリームＢが入力される。ビットストリームＡは、デコーダ２１により復号され、イントラエンコーダ１４１により、Ｉフレームからなる圧縮ビットストリームに再エンコードされる。ビットストリームＢは、デコーダ２２により復号され、イントラエンコーダ１４２により、Ｉフレームからなる

圧縮ビットストリームに再エンコードされる。Ｉフレームのビットストリームｂは、切換スイッチＳ１として示されるスプライサにより、スプライス点Spliceにおいて、Ｉフレームのビットストリームａにスプライスされ、これにより、スプライスされたＩフレームのビットストリームｃが生成される。Ｉフレームのビットストリームｃは、Ｉフレームデコーダ１６及びエンコーダ６により長いＧＯＰの圧縮ビットストリームとして再エンコードされる。エンコーダ６は、コントローラ６１により制御される。コントローラ６１には、復号されたビットストリームから保存された変換パラメータが供給されている。

【００４７】スプライサ４１は、通常、イントラフレームスタジオである。ビットストリームＡＩ及びＢＩは、このイントラフレームスタジオの記録媒体に記録され、スプライシング処理時に読み出される。スプライシングされたビットストリームＣＩをイントラフレームスタジオの記録媒体に記録してもよい。この記録媒体は、テープ状記録媒体及び／又はディスク状記録媒体であってもよい。

【００４８】図８に示すように、時刻ｔ０からスプライス時刻ｔ２以前の期間、ビットストリームＡ０は、デコーダ２１により復号され、イントラフレームエンコーダ１４１により、可能であれば、少なくとも元のビットストリームＡ０のＩフレームの保存された変換パラメータを用いて、Ｉフレームに再エンコードされ、スプライサＳ１の入力端子ＡＩに供給される。一方、ビットストリームＢ０は、デコーダ２２により復号され、イントラフレームエンコーダ１４２により、可能であれば、少なくとも元のビットストリームＢ０のＩフレームの保存された変換パラメータを用いて、Ｉフレームに再エンコードされ、スプライサＳ１の入力端子ＢＩに供給される。時刻ｔ２以前は、スプライサＳ１は、入力端子ＡＩに供給された信号を出力端子ＣＩから出力する。また、スプライサＳ１は、時刻ｔ２以降は、入力端子ＢＩに供給された信号を出力端子ＣＩから出力する。デコーダ１６及びエンコーダ６は、遷移期間である時刻ｔ１から時刻ｔ３の間動作し、この期間においては、スプライスされたビットストリームは、保存されている変換パラメータを使用せず、又は一部のみを使用して再エンコードされる。また、この期間においては、ビットストリームＡのＶＢＶ値からビットストリームＢのＶＢＶ値への遷移が制御されるように再エンコードが行われる。好ましくは、保存されているＩフレームパラメータを用いて、元々ＩフレームであったフレームをＩフレームとして再符号化する。この再符号化の手法は、同時に継続中の欧州特許出願００３０６６９９．６号（代理人番号Ｉ－９９－２１、Ｓ００Ｐ５１３１、Ｐ／７３７４）に開示されており、この出願は、参照により本願に組み込まれるものとする。ビットストリームＣのＶＢＶは、ビットストリームＢのＶＢＶに一致する。時刻ｔ３以降は、好ましくは、全ての変換パラメータを用いてビットストリームＢの再符号化が行われる。時刻ｔ３以降にＶＢＶに乖離が生じた場合、エンコーダ６は、コントローラ６１により制御されて、本発明に基づき、図２、図３及び図４を用いて説明したように動作し、これにより、エンコーダ６により生成されるビットストリームＶＢＶ値の元のビットストリームＢ０からの乖離が低減される。

【００４９】なお、図７及び図８に示す具体例においては、ビットストリームＡ０及びビットストリームＢ０は、時刻ｔ１より先に、Ｉフレームとして復号及び再エンコードされる。ここで、再エンコードが符号化パラメータを完全に再利用する場合、時刻ｔ１以前に、本発明をエンコーダ１４１、１４２に適用してもよい。

【００５０】本発明は、コンピュータプログラムにより制御されるプログラミング可能なデジタルシグナルプロセッサにより実現してもよい。したがって、プロセッサにより実行されて、上述した技術を実現するコンピュータプログラム製品も本発明の一形態である。

【００５１】以上、本発明をＭＰＥＧ２規格に基づいて説明したが、本発明は、他の圧縮方式にも適用できる。

【図面の簡単な説明】

【図１】圧縮ビデオデータをベースバンドに復号し、復号されたビデオデータを処理し、処理されたビデオデータを再エンコードする装置のブロック図である。

【図２】圧縮ビデオデータを復号し、Ｉフレームとして再符号化し、Ｉフレームを処理し、処理されたＩフレームを再エンコードする装置のブロック図である。

【図３】図１、図２、図５又は図７に示す装置の下流のバッファの占有量及び本発明に基づくオーバフローの制御を示す図である。

【図４】図１、図２、図５又は図７に示す装置の下流のバッファの占有量及び本発明に基づくアンダフローの制御を示す図である。

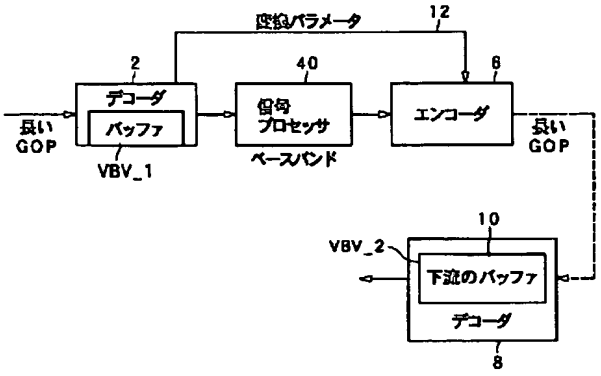
【図５】圧縮ビデオデータをベースバンドに復号し、復号されたビデオデータを編集し、編集されたビデオデータを再エンコードする装置のブロック図である。

【図６】図５に示す装置の動作を説明するタイミングチャートである。

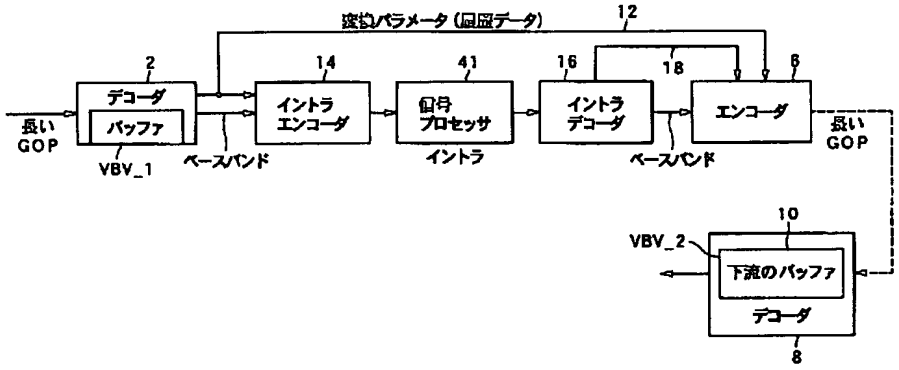
【図７】圧縮ビデオデータを復号し、Ｉフレームとして再符号化し、Ｉフレームを編集し、編集されたＩフレームを再エンコードする装置のブロック図である。

【図８】図７に示す装置の動作を説明するタイミングチャートである。

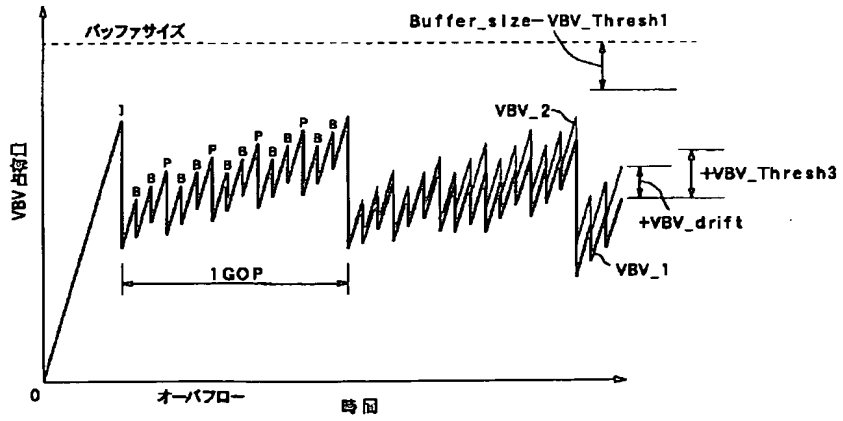
【図１】


変換パラメータ
12
2
デコーダ
バッファ
VBV_1
40
信号
プロセッサ
ベースバンド
6
エンコーダ
長い
GOP
長い
GOP
10
VBV_2
下流のバッファ
デコーダ
8

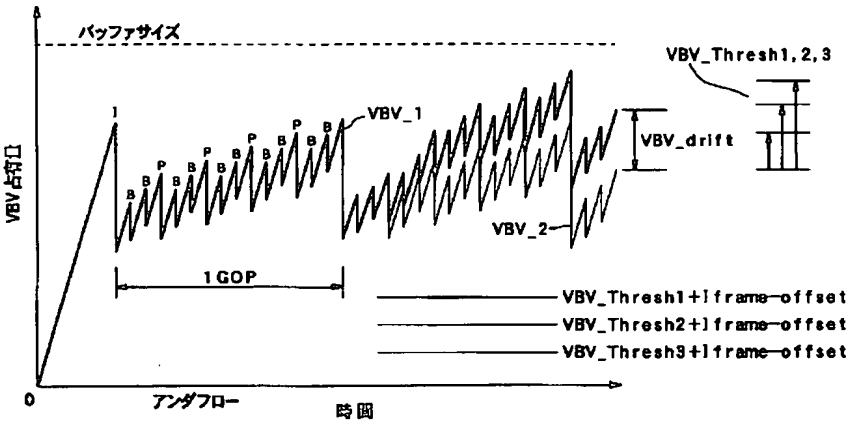
【図２】


変換パラメータ（量子化データ）
12
2
デコーダ
バッファ
VBV_1
14
イントラ
エンコーダ
ベースバンド
41
信号
プロセッサ
イントラ
16
18
イントラ
デコーダ
ベースバンド
6
エンコーダ
長い
GOP
長い
GOP
10
VBV_2
下流のバッファ
デコーダ
8

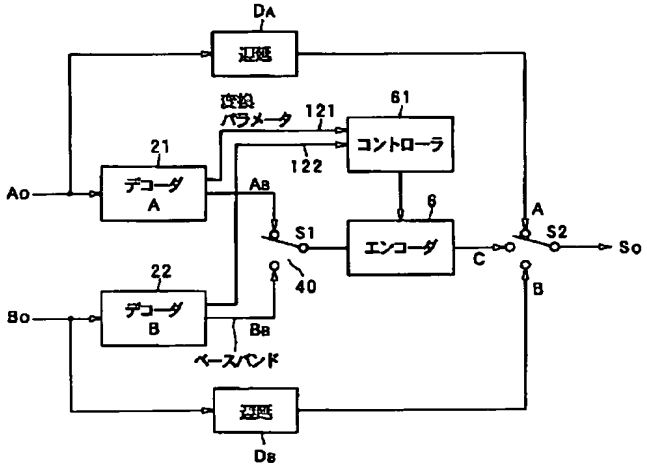
【図３】


バッファサイズ
Buffer_size−VBV_Thresh1
VBV_2
+VBV_Thresh3
+VBV_drift
VBV_1
1GOP
VBV占有
0
オーバフロー
時間

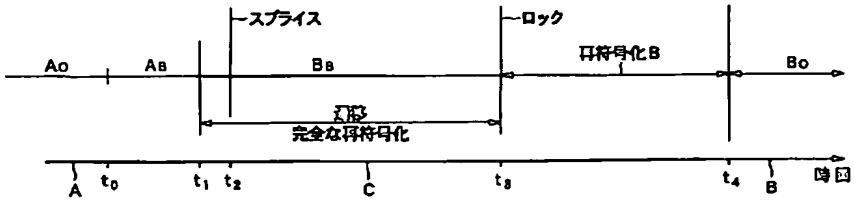
【図４】


バッファサイズ
VBV_Thresh1, 2, 3
VBV_1
VBV_drift
VBV_2
VBV占符口
1GOP
VBV_Thresh1+Iframe-offset
VBV_Thresh2+Iframe-offset
VBV_Thresh3+Iframe-offset
0
アンダフロー
時間

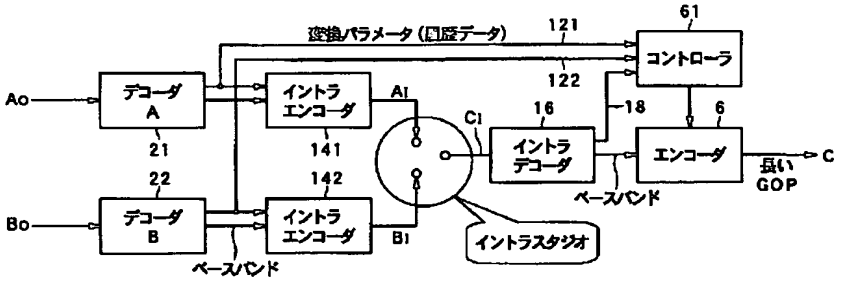
【図５】


DA
遅延
変換パラメータ
121
61
コントローラ
122
21
デコーダA
AB
6
AO
S1
エンコーダ
A
S2
SO
C
40
22
デコーダB
BO
BB
ベースバンド
B
遅延
DB

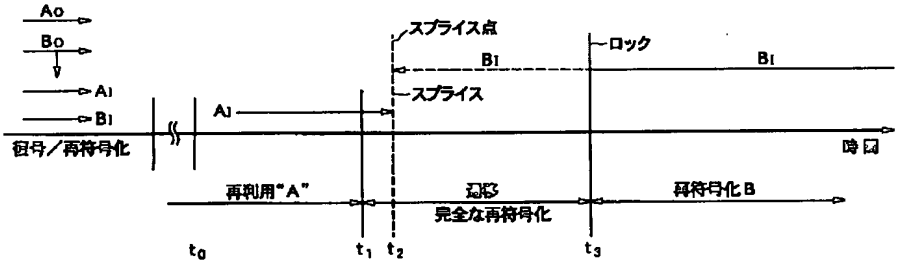
【図６】


スプライス
ロック
AO
AB
BB
再符号化B
BO
遅延
完全な再符号化
A
t0
t1
t2
C
t3
t4
B
時間

【図７】



【図８】



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Ｆターム(参考)　5C053 FA14 GB17 GB28 GB29 GB34
GB38 KA04 LA15
5C059 KK35 KK36 MA00 MA05 MA14
MA23 MC14 MC38 ME01 NN01
NN21 PP05 PP06 PP07 SS06
SS12 TA16 TA24 TA25 TA32
TA47 TA60 TA61 TB08 TC15
TC16 TC18 TC27 TC38 TD12
UA02 UA05 UA32 UA33 UA39

【外国語明細書】

1 Title of Invention

Signal Processing

2 Claims

1. A signal processing system comprising:

a decoder for decoding a first compressed digital video bitstream whilst preserving the compression parameters thereof, the compression parameters including a first buffer occupancy value V_1 representing the occupancy by the said first bitstream of a buffer of the decoder;

a signal processor for processing the decompressed bitstream; and

an encoder for compressing the processed bitstream to produce a second compressed bitstream having a target bit rate, optionally with reuse of the said compression parameters of the first bitstream, the second bitstream having a second occupancy value V_2 representing the occupancy of a downstream decoder buffer by the said second bitstream;

wherein the encoder controls (i) the target bit rate of the second bitstream and (ii) the recoding of the second bitstream to meet the said target bit rate,

the target bit rate being varied in dependence on one or both of (a) V_2 and (b) the difference between V_1 and V_2, and

the degree of reuse of the said preserved parameters being varied in dependence on one or both of (a) the degree to which V_2 tends towards underflow and (b) the degree to which V_1 differs from V_2 tending towards underflow.

2. A system according to claim 1, wherein if V_2 is within a predetermined range of underflow of the downstream buffer, then the second bitstream is encoded without reuse of the preserved parameters, otherwise the second bitstream is encoded with reuse of at least some preserved parameters.

3. A system according to claim 2, wherein if the difference between V_2 and V_1 exceeds a predetermined threshold value tending towards underflow of the downstream buffer, then the second bitstream is encoded without reuse of the preserved parameters, otherwise the second bitstream is encoded with reuse of at least some preserved parameters.

4. A system according to claim 3, wherein the compressed bitstreams comprise groups of intra frames and predicted frames, and if V_2 is less than a first V_2 threshold value Th1 then the target bit rate is reduced by a small amount, and preserved transcoding parameters are reused on intra frames and at least some predicted frames.

5. A system according to claim 3 or 4, wherein the compressed bitstreams comprise groups of intra frames and predicted frames, and if |(V2-V1)| is greater than a first (V2-V1) threshold, then the target bit rate is reduced by a small amount, and preserved transcoding parameters are reused on intra frames and at least some predicted frames.

6. A system according to claim 4 or 5, wherein the groups of frames include I, P and B frames and I and P frames are recoded with reuse of the preserved parameters, and B frames are recoded without reusing preserved parameters

7. A system according to claim 4, 5 or 6, wherein if V_2 is less than a second threshold value Th2 , which is less than the said first threshold Th1 then the target bit rate is reduced by a medium amount, and preserved transcoding parameters are reused on intra frames but not on predicted frames.

8. A system according to claim 4, 5 6 or 7, wherein if |(V2-V1)| is greater than a second (V_2-V_1) threshold but less than a third (V_2-V_1) threshold then the target bit rate is reduced by a medium amount, and preserved transcoding parameters are reused on intra frames but not on predicted frames.

9. A system according to claim 4, 5, 6, 7 or 8, wherein if V_2 is less than a third threshold value Th3 , which is less than the said second threshold Th2, then the target bit rate is reduced by a large amount, and preserved transcoding parameters are not reused on any frames.

10. A system according to claim 4, 5, 6, 7, 8 or 9, wherein if |(V_2-V_1)| is greater than said third (V2-V1) threshold then the target bit rate is reduced by a large amount, and preserved transcoding parameters are not reused on any frames.

11. A system according to any one of claims 1 to 10, wherein stuffing bits are added to the bitstream if V_2 is tending towards overflow of the downstream buffer and/or V_2 differs from V_1 tending towards overflow.

12. A signal processing system comprising:

a decoder for decoding a first compressed digital video bitstream whilst preserving the compression parameters thereof, the compression parameters including a first buffer occupancy value V_1 representing the occupancy by the said first bitstream of a buffer of the decoder;

a signal processor for processing the decompressed bitstream; and

an encoder for compressing the processed bitstream to produce a second compressed bitstream having a target bit rate, optionally with reuse of the said compression parameters of the first bitstream, the second bitstream having a second occupancy value V_2 representing the occupancy of a downstream decoder buffer by the said second bitstream;

wherein the encoder controls (i) the target bit rate of the second bitstream and (ii) the recoding of the second bitstream to meet the said target bit rate, and

if V_2 is tending towards overflow of the downstream buffer and/or V_2 differs from V_1 tending towards overflow of the downstream buffer, the encoder adds stuffing bits to the bitstream and recodes the second bitstream reusing the said preserved parameters.

13. A system according to claim 12, wherein if V_2 is within a threshold range of the buffer size or (V_2 –V_1) exceeds a further threshold level tending towards overflow, then stuffing bits are added to the bitstream.

14. A system according to any preceding claim, wherein the said signal processor comprises one or more of: a store for storing the bitstream; and a

communications channel for transferring the bitstream from the decoder to the encoder.

15. A system according to any preceding claim, wherein the said signal processor comprises an editing apparatus.

16. A system according to any one of claims 1 to 13, wherein the said signal processor comprises an intra-frame encoder to produce an intra frame bitstream, an intra frame signal processor and a decoder for decoding the processed intra frame bitstream to produce the said processed decompressed bitstream.

17. A method of processing a signal comprising the steps of:

decoding a first compressed digital video bitstream whilst preserving the compression parameters thereof, the compression parameters including a first buffer occupancy value V_1 representing the occupancy by the said first bitstream of a buffer of the decoder;

processing the decompressed bitstream; and

compressing the processed bitstream to produce a second compressed bitstream having a target bit rate, optionally with reuse of the said compression parameters of the first bitstream, the second bitstream having a second occupancy value V_2 representing the occupancy of a downstream decoder buffer by the said second bitstream;

wherein the encoding controls (i) the target bit rate of the second bitstream and (ii) the recoding of the second bitstream to meet the said target bit rate,

the target bit rate being varied in dependence on one or both of (a) V_2 and (b) the difference between V_1 and V_2, and

the degree of reuse of the said preserved parameters being varied in dependence on one or both of (a) the degree to which V_2 tends towards underflow and (b) the degree to which V_1 differs from V_2 tending towards underflow.

18. A method of processing a signal comprising the steps of:

decoding a first compressed digital video bitstream whilst preserving the compression parameters thereof, the compression parameters including a first buffer occupancy value V_1 representing the occupancy by the said first bitstream of a buffer of the decoder;

processing the decompressed bitstream; and

compressing the processed bitstream to produce a second compressed bitstream having a target bit rate, optionally with reuse of the said compression parameters of the first bitstream, the second bitstream having a second occupancy value V_2 representing the occupancy of a downstream decoder buffer by the said second bitstream;

wherein the encoding controls (i) the target bit rate of the second bitstream and (ii) the recoding of the second bitstream to meet the said target bit rate, and

if V_2 is tending towards overflow of the downstream buffer and/or V_2 differs from V_1 tending towards overflow of the downstream buffer, the encoder adds stuffing bits to the bitstream and recodes the second bitstream reusing the said preserved parameters.

19 A signal processing system substantially as hereinbefore described with reference to: Figures 1, 3 and 4 optionally as modified by Figures 5 and 6; or Figures 2, 3 and 4 optionally as modified by Figures 7 and 8.

20. A signal processing method substantially as hereinbefore described with reference to: Figures 1, 3 and 4 optionally as modified by Figures 5 and 6; or Figures 2, 3 and 4 optionally as modified by Figures 7 and 8.

21. A computer program product arranged to carry out the method of claim 17, 18 and/or 20 when run on a programmable digital signal processing system.

3 Detailed Description of Invention

The present invention relates to a signal processing system, a method of signal processing and a computer program product arranged to implement the method. Embodiments of the invention relate to processing compressed video bit streams. Preferred embodiments relate to processing video bit streams compressed according to the MPEG 2 standard.

The invention and its background will be discussed by way of example with reference to MPEG-2 video bitstreams. However the invention is not limited to MPEG-2.

MPEG-2 is well known from for example ISO/IEC/13818-2, and will not be described in detail herein. MPEG-2 compressed video comprises groups of I, P and/or B frames known as GOPs, Groups of Pictures. I, P and B frames are well known. An I or Intra-encoded frame contains all the information of the frame independently of any other frame. A P frame in a GOP ultimately depends on an I frame and may depend on other P frames. A B frame of a GOP ultimately depends on an I-frame and may depend on P frames in the GOP. A B frame must not depend on another B frame.

A GOP typically comprises 12 or 15 frames comprising at least one I frame and several P and B frames. To correctly decode a GOP requires all the frames of the GOP, because a large part of the video information required to decode a B frame in the GOP is in a preceding and/or succeeding frame of the GOP. Likewise a large part of the video information required to decode a P frame is in a preceding frame of the GOP. More generally, a GOP must comprise at least one I frame. It may additionally comprise one or more P frames and/or B frames. For example, a GOP may comprise only an I frame and a B frame as in the SX system of SONY.

It is known to edit compressed video or otherwise process it. A known editing process is splicing. Splicing analogue signals is relatively straight forward and can be done at the boundary between adjacent frames, because each analogue frame contains the whole of the video information of that frame independently of other frames. Splicing can be done similarly in the digital domain for both compressed and uncompressed video data if all frames contain the whole video information of the frame. Thus it has been proposed to splice compressed video by reencoding an original

GOP of I and P and/or B frames as all I frames and performing splicing on the I frames and then reencoding the I frames as a new GOP having the same structure as the original GOP. Other processing is also conveniently performed on I frames. Reencoding the original GOP as I frames involves decoding the GOP to baseband and recoding to I frames. Alternatively, it has been proposed to decode a GOP of compressed video to digital baseband (i.e. uncompressed digital video), process the baseband video, and reencode the processed video as a compressed bitstream without the intermediate step of recoding to I frames.

Decoding and reencoding tends to reduce image quality. It is known to maintain image quality by storing the compression parameters of compressed video before it is decompressed and to reuse those stored parameters, for at least frames which have not been changed by the processing, when reencoding the video. For example, I frames of the original compressed video are reencoded as I frames with the same compression parameters as in the original video. Likewise P and B frames of the original video may be reencoded as P and B frames with their original compression parameters. An example of such processing is disclosed in European Patent Application 00306696.6 (Atty. ref. I-99-21 S00P5205EP00, P7374EP).

It is possible that a compressed video bitstream is decoded to I frames or baseband and then reencoded as a compressed bitstream with simple processing which does not change the video such as simple transfer and/or storage.

It has been found that decoding a compressed bitstream to I frames and reencoding the bitstream, whether or not the decoded bitstream is processed so as to change the video, results in the number of bits per GOP of the reencoded bitstream differing from that of the original bitstream even if compression parameters are reused. The same occurs if the compressed bitstream is decoded to baseband and reencoded. This can cause the buffer of a downstream decoder to underflow or overflow.

It is desired to decode and reencode a compressed video bitstream whilst maintaining image quality and avoiding buffer underflow and overflow.

According to a first aspect of the invention, there is provided a signal processing system comprising:

a decoder for decoding a first compressed digital video bitstream whilst preserving the compression parameters thereof, the compression parameters including

a first buffer occupancy value V_1 representing the occupancy by the said first bitstream of a buffer of the decoder;

a signal processor for processing the decompressed bitstream; and

an encoder for compressing the processed bitstream to produce a second compressed bitstream having a target bit rate, optionally with reuse of the said compression parameters of the first bitstream, the second bitstream having a second occupancy value V_2 representing the occupancy of a downstream decoder buffer by the said second bitstream;

wherein the encoder controls (i) the target bit rate of the second bitstream and (ii) the recoding of the second bitstream to meet the said target bit rate,

the target bit rate being varied in dependence on one or both of (a) V_2 and (b) the difference between V_1 and V_2, and

the degree of reuse of the said preserved parameters being varied in dependence on one or both of (a) the degree to which V_2 tends towards underflow and (b) the degree to which V_1 differs from V_2 tending towards underflow.

According to a second aspect of the invention, there is provided a method of processing a signal comprising the steps of:

decoding a first compressed digital video bitstream whilst preserving the compression parameters thereof, the compression parameters including a first buffer occupancy value V_1 representing the occupancy by the said first bitstream of a buffer of the decoder;

processing the decompressed bitstream; and

compressing the processed bitstream to produce a second compressed bitstream having a target bit rate, optionally with reuse of the said compression parameters of the first bitstream, the second bitstream having a second occupancy value V_2 representing the occupancy of a downstream decoder buffer by the said second bitstream;

wherein the encoding controls (i) the target bit rate of the second bitstream and (ii) the recoding of the second bitstream to meet the said target bit rate,

the target bit rate being varied in dependence on one or both of (a) V_2 and (b) the difference between V_1 and V_2, and

the degree of reuse of the said preserved parameters being varied in dependence on one or both of (a) the degree to which V_2 tends towards underflow and (b) the degree to which V_1 differs from V_2 tending towards underflow

According to a third aspect of the invention, there is provided a computer program product comprising instructions which when run on a suitable data processor implement the method of said second aspect of the invention.

Thus the invention avoids underflow whilst preserving image quality by reusing preserved parameters and maintaining a high bit rate when the tendency towards underflow is low, and reduces the reuse of the preserved parameters and reduces the bit rate as the tendency towards underflow increases. Preferably, the values of V_1 and V_2 are controlled so that they converge by controlling the bit rate.

According to a fourth aspect of the invention, there is provided a signal processing system comprising:

a decoder for decoding a first compressed digital video bitstream whilst preserving the compression parameters thereof, the compression parameters including a first buffer occupancy value V_1 representing the occupancy by the said first bitstream of a buffer of the decoder;

a signal processor for processing the decompressed bitstream; and

an encoder for compressing the processed bitstream to produce a second compressed bitstream having a target bit rate, optionally with reuse of the said compression parameters of the first bitstream, the second bitstream having a second occupancy value V_2 representing the occupancy of a downstream decoder buffer by the said second bitstream;

wherein the encoder controls (i) the target bit rate of the second bitstream and (ii) the recoding of the second bitstream to meet the said target bit rate, and

if V_2 is tending towards overflow of the downstream buffer and/or V_2 differs from V_1 tending towards overflow of the downstream buffer, the encoder adds stuffing bits to the bitstream and recodes the second bitstream reusing the said preserved parameters.

According to a fifth aspect of the invention, there is provided a method of processing a signal comprising the steps of:

decoding a first compressed digital video bitstream whilst preserving the compression parameters thereof, the compression parameters including a first buffer occupancy value V_1 representing the occupancy by the said first bitstream of a buffer of the decoder;

processing the decompressed bitstream; and

compressing the processed bitstream to produce a second compressed bitstream having a target bit rate, optionally with reuse of the said compression parameters of the first bitstream, the second bitstream having a second occupancy value V_2 representing the occupancy of a downstream decoder buffer by the said second bitstream;

wherein the encoding controls (i) the target bit rate of the second bitstream and (ii) the recoding of the second bitstream to meet the said target bit rate, and

if V_2 is tending towards overflow of the downstream buffer and/or V_2 differs from V_1 tending towards overflow of the downstream buffer, the encoder adds stuffing bits to the bitstream and recodes the second bitstream reusing the said preserved parameters.

According to a sixth aspect of the invention, there is provided a computer program product comprising instructions which when run on a suitable data processor implement the method of said fifth aspect of the invention.

Thus the invention reduces overflow of the downstream buffer whilst preserving image quality by reusing the preserved parameters and adding stuffing bits.

In preferred embodiments of the invention in which the bitstreams are compresssed according to the MPEG2 standard, V_1 and V_2 are video buffer verifier values VBV_1 and VBV_2.

The illustrative system of Figure 1 comprises a decoder 2 which receives a digital video bitstream compressed according to the MPEG 2 standard. The bitstream comprises a "long GOP" of frames, for example IBBPBBPBBPBB. The decoder 2 decompresses the compressed video to digital baseband. The compression parameters of the I, P and B frames are preserved for transfer to an encoder 6 as indicated by line 12. The parameters include for all frames (i.e. I, P and B):

Identification of the frame type, I P and B;

Quantiser scale;

DCT type (field or frame); and

Quantiser matrix.

The parameters additionally include for predicted frames (i.e. P and B frames):

Prediction type (field or frame);

Macroblock mode; and

Motion vectors.

The decompressed baseband video is applied to a signal processor ,40. The processor 40 may be, inter alia: simply a communications channel for transferring the decompressed video to the encoder 6; a store for storing the baseband video; an image processing system for example an editing system; and/or a video processing studio which operates at digital baseband.

The encoder 6 compresses the video from the processor 40 according to the MPEG2 standard producing in this example a long GOP which is preferably the same as the long GOP supplied to the decoder. The encoder uses the preserved transcoding parameters to compress the processed video and supplies the compressed video to a downstream decoder 8 having a buffer 10.

The system of Figure 2 comprises a decoder 2 which receives a digital video bitstream compressed according to the MPEG 2 standard. The bitstream comprises a "long GOP" of 12 or 15 frames, for example IBBPBBPBBPBB. The decoder 2 decompresses the compressed video to digital baseband. The compression parameters of the I, P and B frames are preserved for transfer to an encoder 6 as indicated by line 12. The compression parameters are the same as set out above with reference to Figure 1.

The decompressed baseband video is applied to an intra-frame encoder 14 which compresses the baseband video to I frames. The intra-encoder 14 uses the preserved parameters of the original I frames to recode those frames as I frames whereever possible within the constraints of the reencoded bitstream. The I frames are supplied to a signal processor 41. The processor 41 may be, inter alia: simply a communications channel for transferring the decompressed video; a store for storing the baseband video; an image processing system for example an editing system; and/or a video processing studio which operates on intra frames.

The processed I frames are supplied to a decoder 16 which decodes them to baseband preserving the compression parameters of the I frames as indicated by line 18 and transfers the baseband video to the encoder 6.

The encoder 6 compresses the video from the decoder 16 according to the MPEG2 standard producing in this example a long GOP which is preferably the same as the long GOP supplied to the decoder 2. The encoder uses the preserved transcoding parameters to compress the processed video and supplies the compressed video to a downstream decoder 8 having a buffer 10.

The decoder 2 of Figures 1 and 2 has a buffer which has an occupancy VBV_1. VBV_1 is known at the decoder 2 by measuring it. The downstream decoder has a buffer the occupancy of which is VBV_2. VBV_2 is estimated at the encoder 6.

In both the systems of Figures 1 and 2, assuming that the processor 40 or 41 simply transfers the video without changing it in any way, it would be expected that, if the compression parameters are reused at the encoder 6 so as to reconstruct at the encoder 6 the long GOP input to the decoder 2, then VBV_1 will be the same as VBV_2. However in practice it is found that VBV_2 differs from VBV_1 and that VBV_1 and VBV_2 tend to drift apart. This is believed to be due to various factors. One factor is rounding errors in the inverse DCT transform in the decoder(s) and in the DCT transforms in the encoder(s). Other factors which arise in the system of Figure 2 are changes in frame type which may arise from the decoding of the original bitstream and reencoding the bitstream; for example a frame which was originally I may be recoded as P or vice versa. In such cases the quantisation scales change. Such errors are likely to be worse in the system of Figure 2 than in the system of Figure 1. Figures 3 and 4 illustrate the drift of VBV_1 and VBV_2. The drift may cause the downstream buffer 10 to underflow or overflow if it is not controlled.

In accordance with an embodiment of the invention, the drift is controlled. Referring to Figures 3 and 4: VBV_2 is the occupancy of the downstream buffer 10 of Figures 1 and 2; VBV_1 is the occupancy of the buffer of the upstream decoder 2; and Buffer_size refers to the size of the downstream buffer 10. Thresholds VBV_Thresh1, VBV_Thresh2, and VBV_Thresh3 are set. These thresholds are all percentages of the Buffer_size. Examples of the thresholds are:

VBV_Thresh1 is 20% of Buffer_size;

VBV_Thresh2 is 15% of Buffer_size; and

VBV_Thresh3 is 10% of Buffer_size.

Figures 3 and 4 show in the heavy line GOPs of the original compressed bitstream input to the upstream decoder 2 and in the light line GOPs of the corresponding recoded bitstream produced by the encoder 6. The GOPs are long GOPs in the example of Figures 3 and 4 having a sequence of 15 frames IBBPBBPBBPBBPBB for example. Each type I, B and P of frame of the original bitstream is recoded as the same type I, B and P respectively of frame by the encoder 6.

A value VBV_drift is determined. VBV_drift is the difference (VBV_2-VBV_1) between the occupancy of the downstream buffer 10 by a frame of the recoded bitsream produced by the encoder 6 and the occupancy of the upstream buffer by the corresponding frame of the original bitstream. VBV_2 is also determined. VBV_2 and VBV_drift are determined once per GOP on the I frame of the GOP in this example. Alternatively, they may be determined on each frame of the GOP or on several but not all frames, for example on I and P frames but not B frames. It is preferable to determine them at least once per GOP on an I frame, because I frames have the greatest occupancy of the buffers and may (but not always) produce the greatest change in occupancy. In other embodiments of the invention, VBV_2 and VBV_drift may be determined every other GOP or at other suitable intervals.

Overflow and positive VBV drift

Referring to Figure 3, which illustrates VBV_2 drifting from VBV_1 with a tendency towards overflow, VBV_drift and VBV_2 are determined once per GOP on the I frame at the start of each GOP..

If (VBV_2 > Buffer_size – VBV_Thresh1) or (VBV_drift > VBV_Thresh3), then stuffing bits are *added* to the GOP following the I frame in the encoder 6 to *reduce* VBV_2. The GOP produced by the encoder reuses all the preserved transcoding parameters when there is a tendency to overflow. By way of explanation, *VBV_2 is the occupancy of the downstream buffer 10.* The occupancy of the downstream buffer is the inverse of the occupancy of the buffer of the encoder.

Adding bits at the encoder to increase its occupancy results in decrease of the occupancy of the downstream buffer.

The threshold Buffer_size – VBV_Thresh1 is shown in Figure 3. If VBV_2 exceeds that threshold the downstream buffer is likely to overflow.

The comparison of VBV_drift with VBV_Thresh3 is also shown in Figure 3. If VBV_2 drifts too far from VBV_1 then that too indicates that the downstream buffer is tending towards overflow. Also, VBV_drift is monitored to ensure that VBV_1 and VBV_2 do not diverge too much. The number of stuffing bits added to the GOP is chosen so as to reduce VBV_2 towards VBV_1 and to allow VBV_2 to remain greater than VBV_1 so as to reduce the likelihood of future underflow. Preferably the stuffing bits are added until VBV_2 = (Buffer_size- VBV_Thresh1) or (VBV_1+ VBV_Thresh3) whichever value of VBV_2 is smaller.

Underflow and negative VBV drift

Referring to Figure 4, which illustrates VBV_2 drifting from VBV_1 with a tendency towards underflow, the same values VBV_drift and VBV_2, which are determined once per GOP on the I frame at the start of each GOP, are used. In addition a value (Iframe_Offset) is used. This is preferably a predetermined fixed value representing the size of a typical I frame. Alternatively, it may be determined for each I frame by measuring the size of the I frame. The I frame_offset allows for the bits removed from the downstream buffer on decoding the I frame at the start of a GOP.

To reduce the likelihood of underflow and to reduce negative VBV drift, the target number of bits per GOP is reduced at the start of each GOP and the degree of reuse of the preserved transcoding parameters is reduced as the drift increases and as the likelihood of underflow increases. To *reduce the likelihood of underflow,* the target number of bits for the GOP is *reduced.* By way of explanation, *VBV_2 is the occupancy of the downstream buffer 10.* The occupancy of the downstream buffer is the inverse of the occupancy of the buffer of the encoder. Reducing the target number of bits at the encoder results in an increase of the occupancy of the downstream buffer.

In the present example:

If (VBV_2 < VBV_Thresh1+ Iframe_Offset) or (VBV_drift < minus VBV_Thresh3) then the target number of bits for the GOP is reduced by a *small*

amount, the preserved transcoding parameters are reused on I and P frames, and B frames are recoded without reusing preserved parameters. These criteria denote a small VBV drift towards underflow. The said *small amount* is for example the value of VBV_drift or a proportion thereof.

If (VBV_2 < VBV_Thresh2+ Iframe_Offset) or (VBVdrift < minus VBV_Thresh2) then the target number of bits for the GOP is reduced by a *medium amount*, the preserved transcoding parameters are reused on I frames, and B and P frames are recoded without reusing preserved parameters. These criteria denote a medium VBV drift towards underflow. The said *medium amount* is for example the value of VBV_drift or a proportion thereof.

If (VBV_2 < VBV_Thresh3+ Iframe_Offset) or (VBVdrift < minus VBV_Thresh1) then the target number of bits for the GOP is reduced by a *large amount*, the preserved transcoding parameters are not reused on any frames, and all the I, P and B frames are recoded without reusing preserved parameters. These criteria denote a large VBV drift towards underflow. The said *large amount* is for example the value of VBV_drift or a proportion thereof.

The amounts by which the target number of bits (and thus bit rate) is changed are chosen to ensure that the rate of change of bit rate is within acceptable bounds.

The above criteria all have two conditions (VBV_2 < VBV_ThreshX+ Iframe_Offset) and (VBVdrift < minus VBV_ThreshY). The decision on how much to reduce the target number of bits and the degree of reuse of the transcoding parameters is preferably decided on the worst case of the two conditions.

In this way, image quality is preserved as much as possible by reusing the transcoding parameters as much as possible.

It will be noted that the condition VBV drift < minus VBV_ThreshY indicates that VBVdrift is more negative than VBV_ThreshY, which is a negative value itself. In terms of magnitude then, |VBVdrift| >|VBV_ThreshY|.

Example of Figures 5 and 6.

Figure 5 shows an illustrative splicing system embodying the invention. Bitstreams A and B which are long GOP compressed bitstreams are supplied to inputs A and B of the system. The bitstream B is decoded to baseband and spliced onto the

decoded baseband bitstream A at a splice point Splice by a splicer shown as a switch S1 to produce a spliced baseband bitstream C which is reencoded by an encoder 6. The encoder 6 is controlled by a controller 61 which receives the preserved transcoding parameters from the decoded bitstreams.

Referring to Figure 6, prior to time t0, a bitstream A0 is fed from the input of a decoder 21 via a delay DA to input A of a switch S2 and thence to the output S0 of the system. From time t1 onwards to the splice time t2, A0 is decoded by decoder 21 to baseband and fed to input A of a splicer S1. A bitstream B0 is also decoded by a decoder 22 to baseband and fed to input B of the splicer S1. Up to time t2, the splicer S1 feeds A to the output C of the splicer. After time t2, the splicer feeds B to the output C. The encoder 6 operates in a transition period t1 to t3 in which the spliced bitstream is fully reencoded without use of, or with partial reuse of, preserved transcoding parameters. During this period reencoding is performed so as to provide a controlled transition from the VBV value of bitstream A to that of bitstream B. Preferably preserved I frame parameters are used to recode frames, which were originally I frames, as I frames. The manner in which that may be done is described in copending European patent application 00306699.0,(attorney reference I-99-19, S99P5130, P/7372) which is incorporated herein by reference. At time t3, the VBV of the bitstream matches that of bitstream B. Recoding of B continues from time t3 to time t4. At time t4, switch S2 switches from input C to input B and compressed bitstream B0 is supplied to the output S0 of the system. During the time period t3 to t4, the encoder operates as described with reference to Figures 1, 3 and 4 in accordance with the invention to reduce any drift of the VBV value of the bitstream produced by the encoder 6 from that of the original bitstream B0 to ensure that at time t4 the VBV values match as closely as possible.

Example of Figures 7 and 8.

Figure 7 shows an illustrative splicing system embodying the invention. Bitstreams A and B which are long GOP compressed bitstreams are supplied to inputs A and B of the system. Bitstream A is decoded by a decoder 21 and reencoded by an intra encoder 141 to a compressed bitstream consisting of I frames. Bitstream B is decoded by a decoder 22 and reencoded by an intra encoder 142 to a compressed bitstream consisting of I frames. I frame bitstream B is spliced onto the I frame

bitstream A at a splice point Splice by a splicer 41 shown as a switch S1 to produce a spliced I frame bitstream C. The I frame bitstream C is reencoded as a long GOP compressed bitstream by an I frame decoder 16 and an encoder 6. The encoder 6 is controlled by a controller 61 which receives the preserved transcoding parameters from the decoded bitstreams.

The splicer 41 is typically in an intra frame studio. The bitstreams AI and BI are preferably stored in stores in the studio to be available for splicing. The spliced bitstream CI may be stored in a store in the studio. The stores may be tape and/or disc stores.

Referring to Figure 8, from time t0 onwards to the splice time t2, A0 is decoded by decoder 21 and reencoded by an intra frame encoder 141 to I frames, reusing ,wherever possible, at least the preserved parameters of the I frames of the original bitstream A0, and fed to input AI of a splicer S1. A bitstream B0 is also decoded by a decoder 22 and reencoded by an I frame encoder 142 to I frames, reusing, wherever possible, at least the preserved parameters of the I frames of the original bitstream Bo, and fed to input BI of the splicer S1. Up to time t2, the splicer S1 feeds A to the output CI of the splicer. After time t2, the splicer feeds B to the output CI. The decoder 16 and encoder 6 operate in a transition period t1 to t3 in which the spliced bitstream is fully reencoded without use of, or with partial use of, preserved transcoding parameters. During this period reencoding is performed so as to provide a controlled transition from the VBV value of bitstream A to that of bitstream B. Preferably preserved I frame parameters are used to recode frames, which were originally I frames, as I frames. The manner in which that may be done is described in copending European patent application 00306696.6,(attorney reference I-99-21, S99P5131, P7374) which is incorporated herein by reference. At time t3, the VBV of the bitstream C matches that of bitstream B. Recoding of B continues from time t3 onwards preferably with full reuse of transcoding parameters. If VBV drift occurs during the time period t3 onwards, the encoder 6 operates, as controlled by controller 61, as described with reference to Figures 2, 3 and 4 in accordance with the invention to reduce any drift of the VBV value of the bitstream produced by the encoder 6 from that of the original bitstream B0.

It will be noted that in the embodiment of Figures 7 and 8, the bitstreams A0 and B0 are decoded and reencoded as I frames prior to time t1. The present invention may be applied in the encoders 141 and 142 prior to time t1 whereever the reencoding makes full reuse of coding parameters.

It will be appreciated that the invention may be implemented in a programmable digital signal processor controlled by a computer program. Thus a computer program product, which implements the techniques described herein when run on the processor, is envisaged as an aspect of this invention.

Whilst the invention has been described in relation to the current MPEG2 standard, it will be appreciated that it could be applied to other compression systems.

4 Brief Description of Drawings

Figure 1 is a schematic block diagram of a system for decoding compressed video to baseband, processing the decoded video and reencoding the processed video;

Figure 2 is a schematic block diagram of a system for decoding compressed video and recoding it as I frames, processing the I frames and reencoding the processed I frames;

Figure 3 is a diagram illustrating occupancy of a down stream buffer of the system of Figure 1, 2, 5 or 7, and illustrating control of overflow in accordance with an embodiment of the invention;

Figure 4 is a diagram illustrating occupancy of a down stream buffer of the system of Figure 1, 2 5 or 7, and illustrating control of underflow in accordance with an embodiment of the invention;

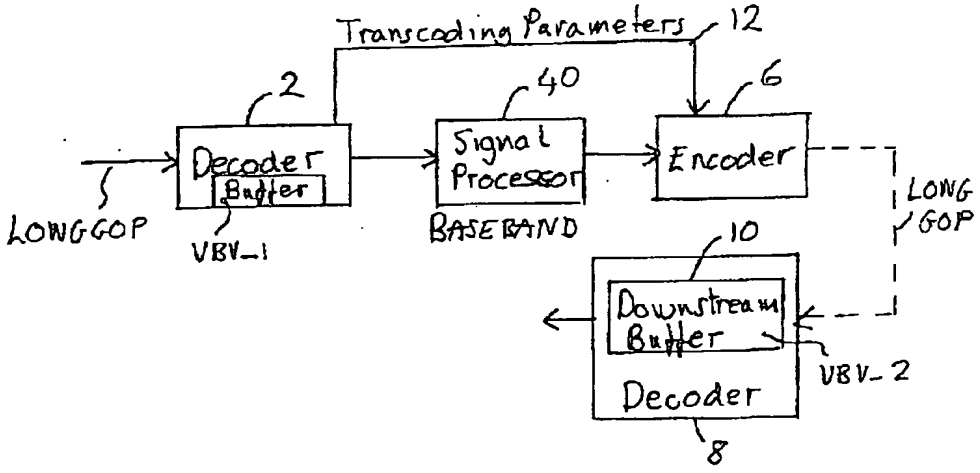
Figure 5 is a schematic block diagram of a system for decoding compressed video to baseband, editing the decoded video and reencoding the edited video;

Figure 6 is a timing diagram for explaining the operation of the system of Figure5;

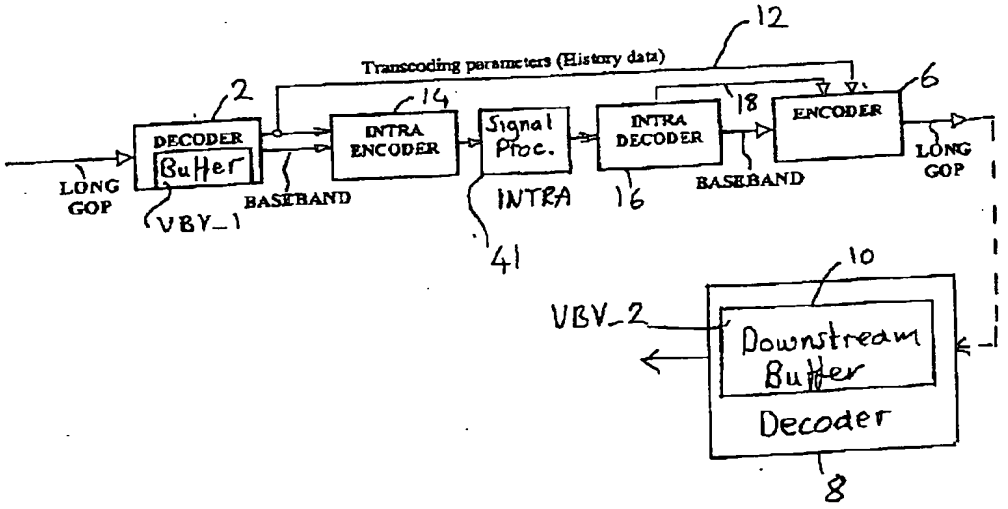
Figure 7 is a schematic block diagram of a system for decoding compressed video and recoding it as I frames, editing the I frames and reencoding the edited I frames; and

Figure 8 is a timing diagram for explaining the operation of the system of Figure 7.

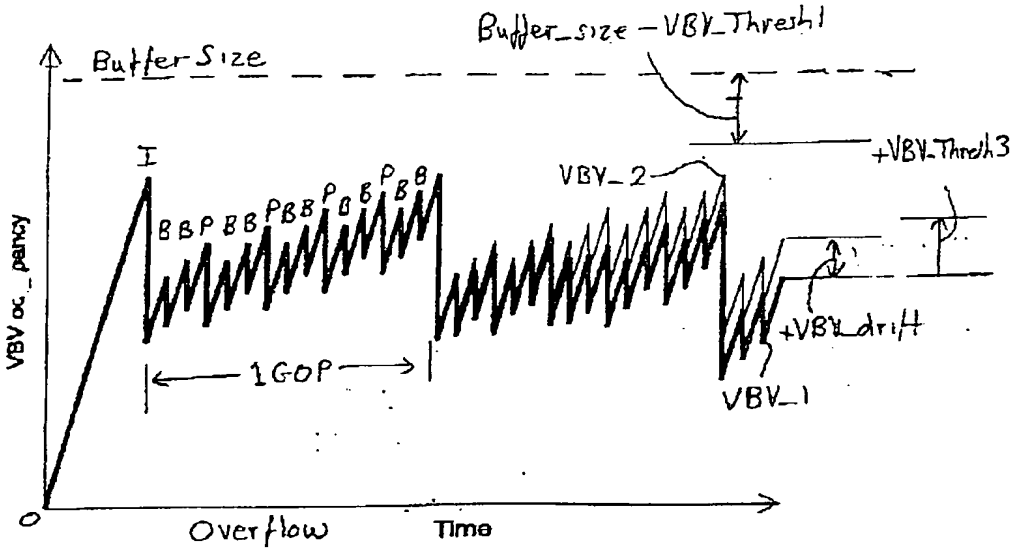
【図１】


Transcoding Parameters
12
2
40
6
Decoder
Buffer
Signal Processor
Encoder
LONG GOP
LONG GOP
VBV_1
BASEBAND
10
Downstream Buffer
VBV_2
Decoder
8

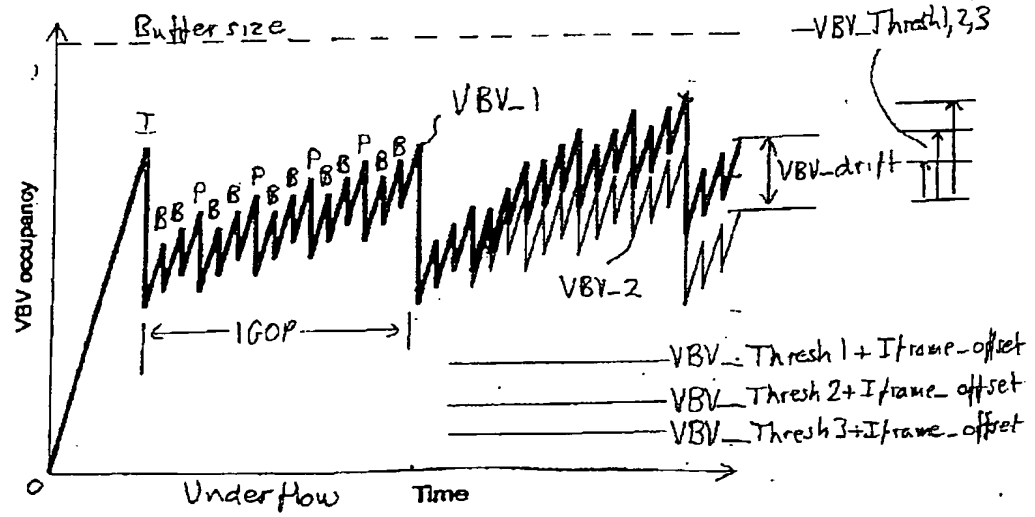
【図２】


12
Transcoding parameters (History data)
2
14
18
6
DECODER
Buffer
INTRA ENCODER
Signal Proc.
INTRA DECODER
ENCODER
LONG GOP
LONG GOP
VBV_1
BASEBAND
INTRA
16
BASEBAND
41
10
VBV_2
Downstream Buffer
Decoder
8

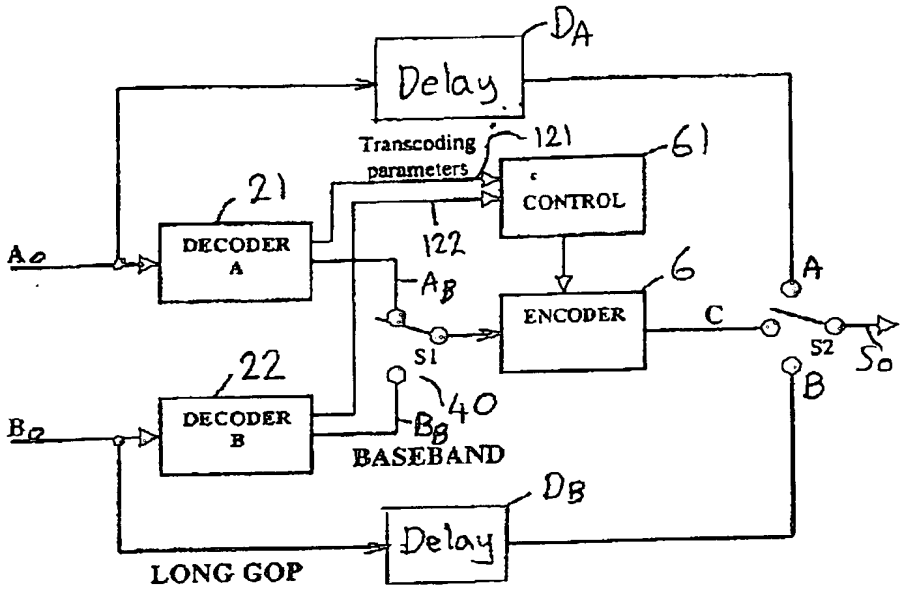
【図３】


Buffer_size－VBV_Thresh1
Buffer Size
+VBV_Thresh3
I
B B P B B P B B P B B P B B
VBV_2
+VBV_drift
1GOP
VBV_1
VBV occupancy
0
Overflow
Time

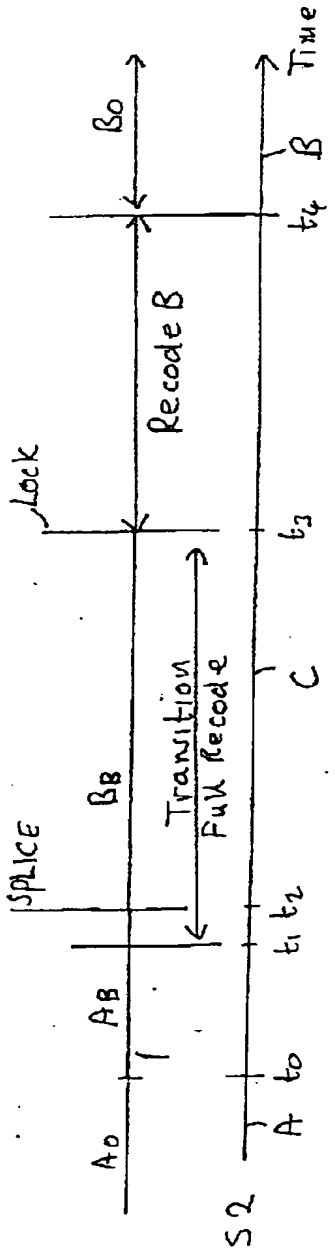
【図４】


Buffer size
VBV_Thresh1,2,3
VBV_1
I
B B P B B P B B P B B P B B
VBV_drift
VBV_2
1GOP
VBV_Thresh1+Iframe_offset
VBV_Thresh2+Iframe_offset
VBV_Thresh3+Iframe_offset
VBV occupancy
0
Underflow
Time

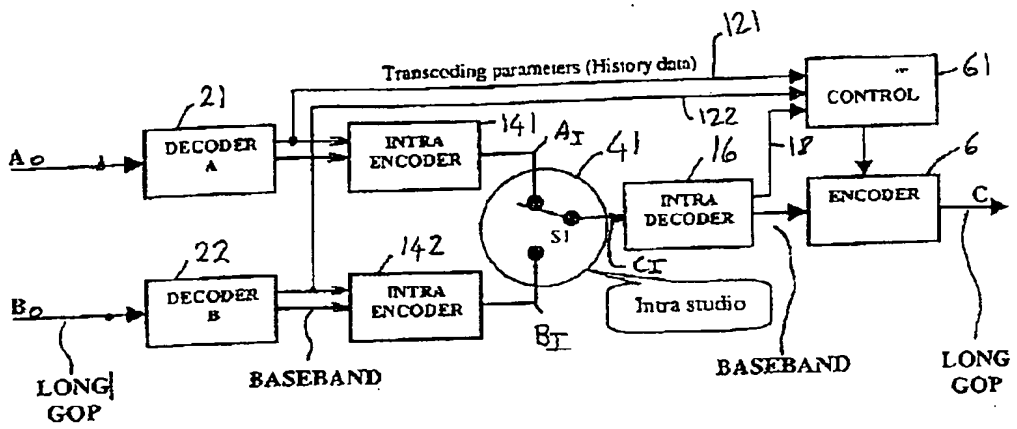
【図５】


Delay
D_A
Transcoding parameters
121
61
CONTROL
21
DECODER A
122
A_o
A_B
6
ENCODER
A
C
S2
S_o
S1
22
DECODER B
40
B_o
B_B
BASEBAND
B
D_B
Delay
LONG GOP

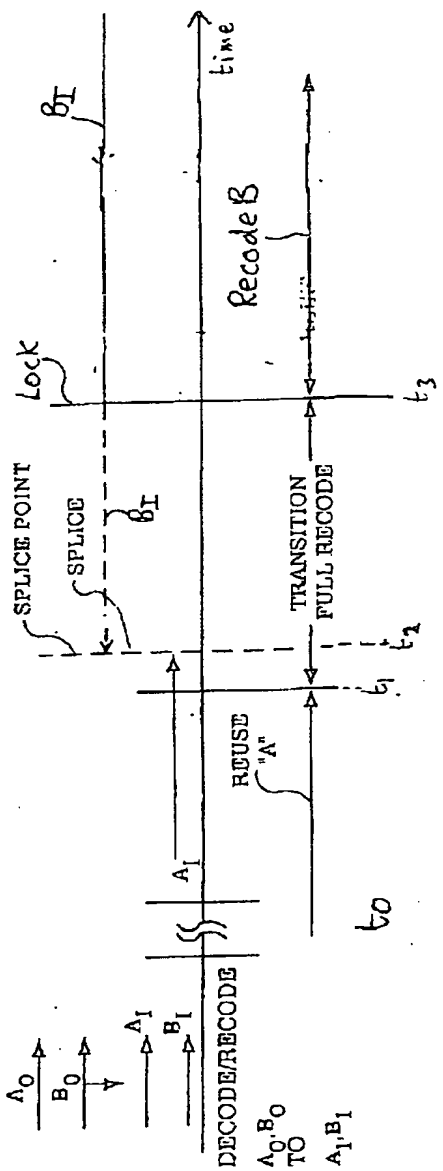
【図６】


Time
B
C
A
B_0
t_4
Recode B
Lock
t_3
Transition
Full Recode
SPLICE
B_B
t_1 t_2
A_B
t_0
A_0
S2

【図７】


Transcoding parameters (History data)
121
CONTROL
61
21
DECODER A
INTRA ENCODER
141
A_I
41
16
INTRA DECODER
18
ENCODER
6
C
A_0
S1
22
DECODER B
142
INTRA ENCODER
B_I
CI
Intra studio
B_0
LONG GOP
BASEBAND
BASEBAND
LONG GOP

【図８】


time
B_I
Recode B
Lock
t_3
SPLICE POINT
SPLICE
B_I
TRANSITION
FULL RECODE
t_2
t_1
REUSE "A"
A_I
t_0
A_0
B_0
A_I
B_I
DECODE/RECODE
A_0, B_0 TO A_1, B_1

1 Abstract

A decoder 2 decodes a first compressed digital video bitstream whilst preserving the compression parameters thereof, the compression parameters including a first buffer occupancy value VBV_1 representing the occupancy by the said first bitstream of a buffer of the decoder. A signal processor 40 processes the decompressed bitstream. An encoder 6 compresses the processed bitstream to produce a second compressed bitstream having a target bit rate, optionally with reuse of the said compression parameters of the first bitstream, the second bitstream having a second occupancy value VBV_2 representing the occupancy of a downstream decoder buffer by the said second bitstream. The encoder controls (i) the target bit rate of the second bitstream and (ii) the recoding of the second bitstream to meet the said target bit rate,

the target bit rate being varied in dependence on one or both of (a) VBV_2 and (b) the difference between VBV_1 and VBV_2, and

the degree of reuse of the said preserved parameters being varied in dependence on one or both of (a) the degree to which VBV_2 tends towards underflow and (b) the degree to which VBV_1 differs from VBV_2 tending towards underflow.

In addition, stuffing bits are added to the bitstream if VBV_2 is tending towards overflow of the downstream buffer and/or VBV_2 differs from VBV_1 tending towards overflow.

2 Representative Drawing

[Figures 1, 3 and 4].

PATENT ABSTRACTS OF JAPAN

(11)Publication number : 2002-320228
(43)Date of publication of application : 31.10.2002

(51)Int.Cl. H04N 7/24
H04N 5/765
H04N 5/91

(21)Application number : 2002-045209
(22)Date of filing : 21.02.2002

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(30)Priority
Priority number : 2001 200104296 Priority date : 21.02.2001 Priority country : GB

(54) SIGNAL PROCESSOR

(57)Abstract:
PROBLEM TO BE SOLVED: To keep image quality and avoid underflow and an over flow of a buffer, when a compressed bit stream is decoded or re-encoded in editing.
SOLUTION: The signal processor includes a decoder for decoding a first compressed digital video bit stream and storing a compression parameter containing a first butter occupied quantity V1 of a decoder, a signal processor for processing an extension bit stream, and an encoder for reusing the selectively the compressed parameter of the first compressed digital bit stream and generating a second compressed bit stream having a second buffer occupied quantity V2 of the downstream decoder. The target bit rate of the encoder is shifted, on the basis of both or one of V2 or on the difference between the V1 and V2. The frequency of reuse of the stored parameters is shifted, on the basis of a degree of tendency of V2 becoming under-flow and a degree of tendency toward underflow while the difference of the V1 and V2 becomes larger.

LEGAL STATUS

[Date of request for examination] 13.10.2004

[Date of sending the examiner's decision of rejection]

[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]

[Date of final disposal for application]

[Patent number]

[Date of registration]

[Number of appeal against examiner's decision of rejection]

[Date of requesting appeal against examiner's decision of rejection]

[Date of extinction of right]

CLAIMS

[Claim(s)]

[Claim 1] the 1st compression digital video bit stream is decoded, and the 1st buffer occupation V_1 showing the occupation of the buffer of the decoder by the 1st bit stream is included -- this -- with the decoder which saves the compression parameter of the 1st compression digital video bit stream The elongation bit stream by which processing was carried out [above-mentioned] with the signal processor which processes an elongation bit stream is compressed. The compression parameter of the compression digital bit stream of the above 1st is reused alternatively. It has the encoder which generates the 2nd compression bit stream which has a target bit rate and has the 2nd buffer occupation V_2 showing the occupation of the buffer of the decoder of the lower stream of a river by the 2nd bit stream. The above-mentioned encoder controls the target bit rate of the 2nd bit stream of (i) above, and recoding of the 2nd bit stream of (ii) above, and this target bit rate is attained. The above-mentioned target bit rate is changed based on both (a) V_2, (b) V_1, and Vboth [either or] of a difference, and the degree of the reuse of a compression parameter by which preservation was carried out [above-mentioned] (a) Signal processor characterized by being changed based on both both [either or] of a degree which the degree of the inclination for V_2 to become an underflow, and the difference of (b) V_1 and V_2 become large, and an underflow produces.

[Claim 2] It is the signal processor according to claim 1 characterized by encoding the 2nd bit stream of the above, without reusing the compression parameter by which preservation was carried out [above-mentioned], and in other than this for

the 2nd bit stream of the above reusing a part of compression parameter [at least] by which preservation was carried out [above-mentioned], and encoding it when the above V_2 is within the limits of predetermined [corresponding to the underflow of a down-stream buffer].

[Claim 3] It is the signal processor according to claim 2 characterized by encoding the 2nd bit stream of the above, without reusing the saved compression parameter, and in other than this for the 2nd bit stream of the above reusing a part of compression parameter [at least] by which preservation was carried out [above-mentioned], and encoding it when the above V_2 and the difference of V_1 exceed the predetermined threshold which makes a down-stream buffer produce an underflow.

[Claim 4] the above-mentioned compression bit stream -- intra -- the conversion parameter by which it consisted of a group of a frame and a prediction frame, the above-mentioned target bit rate decreased the number of some when V_2 was smaller than the 1st V_2 threshold Th 1, and preservation was carried out [above-mentioned] -- intra -- the signal processor according to claim 3 characterized by being reused to a frame and the prediction frame of at least a part.

[Claim 5] the above-mentioned compression video stream -- intra -- the conversion parameter by which it consisted of a group of a frame and a prediction frame, as for the above-mentioned target bit rate, |V_2-V_1| decreased the number of some when larger than the 1st threshold (V_2-V_1), and preservation was carried out [above-mentioned] -- intra -- the signal processor according to claim 3 or 4 characterized by being reused to a frame and the prediction frame of at least a part.

[Claim 6] It is the signal processor according to claim 4 or 5 which the group of the above-mentioned frame reuses the parameter with which preservation of I frames and the P frames was carried out [above-mentioned] including I frames, P frames, and B frames, and recoding is carried out, and is characterized by carrying out recoding of the B frames, without reusing the parameter by which preservation was carried out [above-mentioned].

[Claim 7] the conversion parameter by which frequency reduction of the above-mentioned target bit rate was carried out in the middle, and preservation was carried out [above-mentioned] when the above V_2 was smaller than the 2nd threshold Th 2 smaller than the threshold Th 1 of the above 1st -- intra -- a signal processor claim 4 characterized by being reused by only the frame and not being reused by the prediction frame thru/or given in 6 any 1 terms.

[Claim 8] | the conversion parameter by which V_2-V_1| was larger than the 2nd threshold (V_2-V_1), frequency reduction of the above-mentioned target bit rate was carried out in the middle when smaller than the 3rd threshold (V_2-V_1), and preservation was carried out [above-mentioned] -- intra -- a signal processor claim 4 characterized by being reused by only the frame and not being reused by the prediction frame thru/or given in 7 any 1 terms.

[Claim 9] When the above V_2 is smaller than the 3rd threshold Th 3 smaller than the threshold Th 2 of the above 2nd, for the conversion parameter by which

preservation was decreased and carried out [above-mentioned], the above-mentioned target bit rate is a signal processor claim 4 characterized by not being reused by any frames thru/or given in 8 any 1 terms an extensive number.
[Claim 10] | For V_2-V_1|, when larger than the 3rd threshold (V_2-V_1) of the above, the above-mentioned target bit rate is [the conversion parameter by which preservation was decreased and carried out / above-mentioned] a signal processor claim 4 characterized by not being reused by any frames thru/or given in 9 any 1 terms an extensive number.
[Claim 11] Claim 1 characterized by adding a stuffing bit to the above-mentioned bit stream when the above V_2 shows the inclination of the overflow in a down-stream buffer and/or the difference from V_1 of V_2 shows the inclination of overflow thru/or a signal processor given in 10 any 1 terms.
[Claim 12] the 1st compression digital video bit stream is decoded, and the 1st buffer occupation V_1 showing the occupation of the buffer of the decoder by the 1st bit stream is included -- this -- with the decoder which saves the compression parameter of the 1st compression digital video bit stream The elongation bit stream by which processing was carried out [above-mentioned] with the signal processor which processes an elongation bit stream is compressed. The compression parameter of the compression digital bit stream of the above 1st is reused alternatively. It has the encoder which generates the 2nd compression bit stream which has a target bit rate and has the 2nd buffer occupation V_2 showing the occupation of the buffer of the decoder of the lower stream of a river by the 2nd bit stream. The above-mentioned encoder controls the target bit rate of the 2nd bit stream of (i) above, and recoding of the 2nd bit stream of (ii) above, and this target bit rate is attained. When the above V_2 shows the inclination of the overflow in a down-stream buffer and/or the difference from V_1 of V_2 shows the inclination of overflow, the above-mentioned encoder The signal processor characterized by carrying out recoding of the 2nd bit stream of the above using the parameter by which added the stuffing bit to the above-mentioned bit stream, and preservation was carried out [above-mentioned].
[Claim 13] The signal processor according to claim 12 characterized by adding a stuffing bit to a bit stream when the above V_2 exceeds the further threshold level which shows less than the threshold of buffer size, or (V_2-V1) overflow.
[Claim 14] The above-mentioned signal processor is a signal processor claim 1 characterized by having the communication channel which transmits a bit stream to an encoder from one or more record media which record a bit stream, and the above-mentioned decoder thru/or given in 13 any 1 terms.
[Claim 15] The above-mentioned signal processor is a signal processor claim 1 characterized by having edit equipment thru/or given in 14 any 1 terms.
[Claim 16] the above-mentioned signal processor -- intra -- the intra which generates the bit stream of a frame -- a frame encoder and intra -- the intra processed with the frame signal processor -- a signal processor claim 1 characterized by having the decoder which decodes the bit stream of a frame and generates the elongation bit stream by which processing was carried out [above-

mentioned] thru/or given in 13 any 1 terms.
[Claim 17] the 1st compression digital video bit stream is decoded, and the 1st buffer occupation V_1 showing the occupation of the buffer of the decoder by the 1st bit stream is included -- this -- with the step which saves the compression parameter of the 1st compression digital video bit stream The step which processes an elongation bit stream, and the elongation bit stream by which processing was carried out [above-mentioned] are compressed. The compression parameter of the compression digital bit stream of the above 1st is reused alternatively. It has the step which generates the 2nd compression bit stream which has a target bit rate and has the 2nd buffer occupation V_2 showing the occupation of the buffer of the decoder of the lower stream of a river by the 2nd bit stream. In encoding processing, control the target bit rate of the 2nd bit stream of (i) above, and recoding of the 2nd bit stream of (ii) above, and this target bit rate is attained. The above-mentioned target bit rate is changed based on both (a) V_2, (b) V_1, and Vboth [either or] of a difference, and the degree of the reuse of a parameter by which preservation was carried out [above-mentioned] (a) The signal-processing approach characterized by being changed based on both both [either or] of a degree which the degree of the inclination for V_2 to become an underflow, and the difference of (b) V_1 and V_2 become large, and an underflow produces.
[Claim 18] the 1st compression digital video bit stream is decoded, and the 1st buffer occupation V_1 showing the occupation of the buffer of the decoder by the 1st bit stream is included -- this -- with the step which saves the compression parameter of the 1st compression digital video bit stream The step which processes an elongation bit stream, and the elongation bit stream by which processing was carried out [above-mentioned] are compressed. The compression parameter of the compression digital bit stream of the above 1st is reused alternatively. It has the step which generates the 2nd compression bit stream which has a target bit rate and has the 2nd buffer occupation V_2 showing the occupation of the buffer of the decoder of the lower stream of a river by the 2nd bit stream. In encoding processing, control the target bit rate of the 2nd bit stream of (i) above, and recoding of the 2nd bit stream of (ii) above, and this target bit rate is attained. When the above V_2 shows the inclination of the overflow in a down-stream buffer and/or the difference from V_1 of V_2 shows the inclination of overflow, the above-mentioned encoder The signal-processing approach characterized by carrying out recoding of the 2nd bit stream of the above using the parameter by which added the stuffing bit to the above-mentioned bit stream, and preservation was carried out [above-mentioned].
[Claim 19] The signal processor which explained using drawing 1 , drawing 3 , and drawing 4 , explained using drawing 2 , drawing 3 , and drawing 4 using drawing 5 and drawing 6 or it was changed into arbitration, and was changed into arbitration using drawing 7 and drawing 8 .
[Claim 20] The signal-processing approach which explained using drawing 1 , drawing 3 , and drawing 4 , explained using drawing 2 , drawing 3 , and drawing 4

using drawing 5 and drawing 6 or it was changed into arbitration, and was changed into arbitration using drawing 7 and drawing 8 .
[Claim 21] The computer program product which is performed in a programmable signal processor and realizes the signal-processing approach of a publication to claims 17 and 18 and/or 20.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001] This invention relates to a signal processor, the signal-processing approach, and the computer program product that realizes this signal-processing approach. The gestalt of operation of this invention is related with processing of a compression video bit stream. The gestalt of desirable operation of this invention is related with processing of the video bit stream compressed based on MPEG 2 specification.
[0002] In this invention and its background, although an MPEG 2 video bit stream is explained to an example, this invention is not limited to processing of an MPEG 2 video bit stream.
[0003] For example, by International Organization for Standardization (International Standardization Organization:ISO) / Kokusai Electric technical committee (International ElectrotechnicalCommission:IEC) / 13818-2 grade, MPEG 2 is common knowledge and is not explained to a detail here. MPEG 2 compression video consists of groups of I frames, P frames, and/or B frames known as the GRU PUOBU picture (Groups of Pictures), i.e., GOP. About I frames, P frames, and B frames, it is common knowledge. I frames, i.e., intra, -- an encoding frame becomes independent of any of other frames, and includes the information on the whole frame. Although P in GOP are finally dependent on I frames, they may be dependent on other P frames. Although B in GOP are finally dependent on I frames, they may be dependent on P in GOP. It cannot be depended for B frames on other B frames.
[0004] GOP usually consists of 12 pieces or 15 frames which consist of at least one frames [I], two or more P frames, and two or more B frames. Since it is contained in the frame preceded and/or followed in GOP, in order to decode GOP correctly, all the frames in GOP are required for the great portion of video information required in order to decode B frames. The great portion of video information required similarly, in order to decode P frames is included in the frame preceded in GOP. Therefore, GOP needs to contain at least one frames [I]. Furthermore, GOP can have one or more frames [P] and/or B frames. GOP may consist of only one frames [I] and one frames [B] like SX equipment of for example, Sony Corp.
[0005] The technique of performing edit and other processings is known to the compression video data. There is splicing processing (splicing) as well-known edit

processing. Since each frame of an analog signal has been independent of other frames and includes the whole video information on the frame, splicing processing of an analog signal is comparatively simple, and can be performed on an adjoining inter-frame boundary. If all frames include the whole video information on each frame, same splicing processing can be performed in a digital field also with the video data which is not compressed about the compressed video data, either. Then, in order to perform splicing processing to a compression video data, re-encoding (reencoding) of all the GOP(s) of the origin which consists of I, P, and/or B frames is carried out to I frames, splicing processing is performed to these I frames, and the technique further re-encoded to new GOP which has such structures as the original GOP where I frames is the same is proposed. To I frames, other processings do not interfere and can be performed. In order to re-encode all the original GOP(s) to I frames, it is necessary to decode GOP to baseband (decoding) and to carry out recoding (recoding) to I frames. It replaces with this, GOP of a compression video data is decoded to digital baseband (namely, incompressible video data), a baseband video data is processed, the middle step of recoding of I frames is skipped, and the technique of making this processed video data a compression bit stream, and re-encoding it is also proposed.

[0006] Image quality tends to deteriorate by decode processing and re-encoding processing. Then, in case the compression parameter of a compression video data is saved and a video data is re-encoded before elongating a video data, to the frame which is not changed by processing at least, the technique of maintaining image quality is known by reusing this saved parameter. For example, I frames of the original compression video data are re-encoded as I frames with the same compression parameter as the original video data. Similarly, P of the original video data and B frames can be re-encoded as P and B frames using the original compression parameter. The example of such processing is indicated by the Europe patent application 00306696.No. (the surrogate number I-99-21, S00P5205EP [00], P7374EP) 6.

[0007] After decoding a compression video bit stream to I frames or baseband, transmission, record, etc. can also re-encode them, being able to use the decoded data as a compression bit stream, while performing simple processing which does not change a video data.

[0008] Even if it was not concerned with whether the bit stream decoded by decoding a compression bit stream to I frames, and re-encoding a bit stream here changes video information but reused the compression parameter, it was found out that the number of bits for every GOP of the re-encoded bit stream and the number of bits for every GOP of the original bit stream change. Moreover, also when re-encoding after decoding a compression bit stream to baseband, the same phenomenon arises. Thereby, an underflow or overflow may take place in the buffer of a down-stream decoder.

[0009] Then, decode and in case it re-encodes, while maintaining image quality for a compression video bit stream, to avoid the underflow of a buffer and overflow is desired.

[0010] The signal processor which is the 1st gestalt of this invention decodes the 1st compression digital video bit stream. The decoder which saves the compression parameter of the 1st compression digital video bit stream containing the 1st buffer occupation V_1 showing the occupation of the buffer of the decoder by the 1st bit stream, The elongation bit stream processed with the signal processor which processes an elongation bit stream is compressed. The compression parameter of the 1st compression digital bit stream is reused alternatively. It has the encoder which generates the 2nd compression bit stream which has a target bit rate and has the 2nd buffer occupation V_2 showing the occupation of the buffer of the decoder of the lower stream of a river by the 2nd bit stream. An encoder controls the target bit rate of the (i) 2nd bit stream, and recoding of the 2nd bit stream of (ii), and a target bit rate is attained. A target bit rate is changed based on both (a) V_2, (b) V_1, and Vboth [either or] of a difference, and the degree of reuse of the saved parameter (a) The degree of the inclination for V_2 to become an underflow, and the difference of (b) V_1 and V_2 become large, and it is changed based on both both [either or] of a degree which an underflow produces.

[0011] The signal-processing approach which is the 2nd gestalt of this invention decodes the 1st compression digital video bit stream. The step which saves the compression parameter of the 1st compression digital video bit stream containing the 1st buffer occupation V_1 showing the occupation of the buffer of the decoder by the 1st bit stream, The step which processes an elongation bit stream, and the processed elongation bit stream are compressed. The compression parameter of the 1st compression digital bit stream is reused alternatively. It has the step which generates the 2nd compression bit stream which has a target bit rate and has the 2nd buffer occupation V_2 showing the occupation of the buffer of the decoder of the lower stream of a river by the 2nd bit stream. In encoding processing, control the target bit rate of the (i) 2nd bit stream, and recoding of the 2nd bit stream of (ii), and a target bit rate is attained. A target bit rate is changed based on both (a) V_2, (b) V_1, and Vboth [either or] of a difference, and the degree of reuse of the saved parameter (a) The degree of the inclination for V_2 to become an underflow, and the difference of (b) V_1 and V_2 become large, and it is changed based on both both [either or] of a degree which an underflow produces.

[0012] The computer program product which is the 3rd gestalt of this invention is performed on a suitable data processor, and realizes the above-mentioned signal-processing approach.

[0013] When possibility that an underflow will arise is low, maintaining image quality by reusing the saved parameter by this invention, a bit rate is maintained highly, and the degree and bit rate of reuse of a parameter which were saved are reduced as possibility that an underflow will arise becomes high. Preferably, by carrying out bit rate control, the value of V_1 and V_2 is controlled so that it is completed by these values.

[0014] The signal processor which is the 4th gestalt of this invention decodes the 1st compression digital video bit stream. The decoder which saves the

compression parameter of the 1st compression digital video bit stream containing the 1st buffer occupation V_1 showing the occupation of the buffer of the decoder by the 1st bit stream, The elongation bit stream processed with the signal processor which processes an elongation bit stream is compressed. The compression parameter of the 1st compression digital bit stream is reused alternatively. It has the encoder which generates the 2nd compression bit stream which has a target bit rate and has the 2nd buffer occupation V_2 showing the occupation of the buffer of the decoder of the lower stream of a river by the 2nd bit stream. An encoder controls the target bit rate of the (i) 2nd bit stream, and recoding of the 2nd bit stream of (ii), and a target bit rate is attained. When V_2 shows the inclination of the overflow in a down-stream buffer and/or the difference from V_1 of V_2 shows the inclination of overflow, an encoder Recoding of the 2nd bit stream is carried out using the parameter which added the stuffing bit to the bit stream and was saved.

[0015] The signal-processing approach which is the 5th gestalt of this invention decodes the 1st compression digital video bit stream. The step which saves the compression parameter of the 1st compression digital video bit stream containing the 1st buffer occupation V_1 showing the occupation of the buffer of the decoder by the 1st bit stream, The step which processes an elongation bit stream, and the processed elongation bit stream are compressed. The compression parameter of the 1st compression digital bit stream is reused alternatively. It has the step which generates the 2nd compression bit stream which has a target bit rate and has the 2nd buffer occupation V_2 showing the occupation of the buffer of the decoder of the lower stream of a river by the 2nd bit stream. In encoding processing, control the target bit rate of the (i) 2nd bit stream, and recoding of the 2nd bit stream of (ii), and a target bit rate is attained. When V_2 shows the inclination of the overflow in a down-stream buffer and/or the difference from V_1 of V_2 shows the inclination of overflow, an encoder It is characterized by carrying out recoding of the 2nd bit stream using the parameter which added the stuffing bit to the bit stream and was saved.

[0016] The computer program product which is the 6th gestalt of this invention is performed on a suitable data processor, and realizes the signal-processing approach which is the 5th gestalt of this invention.

[0017] According to this invention, the overflow in a down-stream buffer can be prevented, maintaining image quality by reusing the saved parameter and adding a stuffing bit.

[0018] The equipment shown in drawing 1 is equipped with the decoder 2 to which the digital bit stream compressed based on MPEG 2 specification is supplied. The bit stream contains "long GOP" of a frame called IBBPBBPBBPBB etc. A decoder 2 elongates a compression video bit stream to digital baseband. I, P, and the compression parameter (compression parameter) of B frames are saved in order to transmit to an encoder 6, as a line 12 shows. These compression parameters include the following information about all frames (namely, I, P, and B frames).

[0019] The frame type identification information I and P, a B quantization scale

DCT type (the field or frame)
Quantization matrix (Quantiser matrix)
Furthermore, the compression parameter includes the following information about the prediction frame (namely, P and B frames).
[0020] Prediction type (the field or frame)
The baseband video bit stream by which macro block mode motion vector elongation was carried out is supplied to a signal processor 40. You may be a mere communication channel for transmitting an elongation video data to an encoder 6, and especially the signal processor 40 may be preservation equipment for saving a baseband video data, and may be image processing systems, such as edit equipment, and/or may be video-processing studio which processes digital baseband signaling.
[0021] Based on MPEG 2 specification, an encoder 6 compresses the video data from a signal processor 40, and generates preferably long GOP supplied to the decoder 2, and same long GOP in this example. An encoder 6 compresses the processed video data using the saved conversion parameter (transcoding parameter), and supplies this compression video data to the down-stream decoder 8 which has a buffer 10.
[0022] The equipment shown in drawing 2 is equipped with the decoder 2 to which the digital bit stream compressed based on MPEG 2 specification is supplied. The bit stream contains "long GOP" of a frame called IBBPBBPBBPBB etc. A decoder 2 elongates a compression video bit stream to digital baseband. I, P, and the compression parameter of B frames are saved in order to transmit to an encoder 6, as a line 12 shows. These compression parameters are the same as the parameter explained using drawing 1 .
[0023] the elongated baseband video data -- intra -- the frame encoder (intra-frame encoder) 14 is supplied -- having -- intra -- the frame encoder 14 compresses a baseband video data into I frames. intra -- as long as constraint of the bit stream re-encoded allows, using the saved original compression parameter of I frames, the frame encoder 14 makes each frame I frames, and carries out recoding. These I frames are supplied to a signal processor 41. the preservation equipment for especially the signal processor 41 being a mere communication channel for transmitting an elongation video data to an encoder 6, and saving a baseband video data -- you may be -- image processing systems, such as edit equipment, -- you may be -- and/or, intra -- you may be the video-processing studio which processes frame information.
[0024] I processed frames are supplied to a decoder 16, and as a line 18 shows, a decoder 16 saves the compression parameter of I frames, and supplies a baseband video data to an encoder 6, while it decodes I these-processed frames to baseband.
[0025] Based on MPEG 2 specification, an encoder 6 compresses the video data from a decoder 16, and generates preferably long GOP supplied to the decoder 2, and same long GOP in this example. An encoder 6 compresses the processed video data using the saved conversion parameter, and supplies this compression

video data to the down-stream decoder 8 which has a buffer 10.
[0026] The decoder 2 shown in drawing 1 and drawing 2 is equipped with a buffer, and sets the occupation (occupancy) to VBV_1. VBV_1 is understood by measuring it in a decoder 2. The down-stream decoder 8 is equipped with a buffer, and sets the occupation to VBV_2. VBV_2 are presumed in an encoder 6.
[0027] Also in any of the equipment shown in drawing 1 and drawing 2 , if it assumes that it transmits without signal processors 40 and 41 changing a video data at all, in an encoder 6, a compression parameter is reused, and when reconstructing long GOP supplied to the decoder 2, VBV_1 will become the same as VBV_2. However, in fact, VBV_2 differed from VBV_1 and what (drift apart) VBV_2 deviate from VBV_1 gradually was found out. Various things can be considered as this factor. First, the rounding error at the time of the reverse DCT conversion in a decoder 2 and the DCT conversion in an encoder 6 is one of the factors. Furthermore, in the equipment shown in drawing 2 , by decoding the original bit stream and re-encoding a bit stream, the frame which were turns into P frames, or, for origin, it is also one of the factors that frame types, such as the reverse, will be changed. In such a case, a quantization scale changes. In the equipment shown in drawing 2 , it is easy to produce such an error rather than the equipment shown in drawing 1 . Drawing 3 and drawing 4 are drawings showing deviation of VBV_1 and VBV_2. If such deviation is not controlled, an underflow or overflow may arise in the down-stream buffer 10.
[0028] This deviation is controlled in the gestalt of desirable operation of this invention. Drawing 3 and drawing 4 are explained. VBV_2 are the occupation of the buffer 10 of the lower stream of a river shown in drawing 1 and drawing 2 . VBV_1 is the occupation of the buffer of the upstream decoder 2. Buffer_size is the buffer capacity of the down-stream buffer 10. Threshold VBV_Thresh1, VBV_Thresh2, and VBV_Thresh3 are determined by setup. All of these thresholds are set up as a percentage of Buffer_size. The example of a threshold is shown below.
[0029] The thick wire which shows VBV_Thresh3 which makes VBV_Thresh2 which makes VBV_Thresh1 20% of Buffer_size 15% of Buffer_size to drawing 3 and drawing 4 which are made into 10% of Buffer_size shows GOP of the compression bit stream of the origin supplied to the upstream decoder 2, and a thin line shows GOP of the corresponding recoding bit stream generated by the encoder 6. These GOP(s) are long GOP(s) which have the sequence of 15 frames of IBBPBBPBBPBBPBB, for example by the example shown in drawing 3 and drawing 4 . Recoding of each I [in the original bit stream], B, and the P frames is carried out to I respectively same type, P, and B frames by the encoder 6.
[0030] Here, value VBV_drift is computed. VBV_drift is the difference between the occupation of the buffer 10 of the lower stream of a river by the frame of the recoding bit stream generated by the encoder 6, and the occupation of the buffer of the upstream by the corresponding frame in the original bit stream (VBV_2-VBV_1). VBV_2 are calculated. VBV_2 and VBV_drift are calculated by a unit of 1 time for every GOP in I in GOP in this example. It may replace with this and these values may be calculated in each frame of GOP, for example, except for B frames,

although I frames, P etc. frames, etc. are not all frames, you may ask for them in two or more frames. Its occupation of a buffer (that may not necessarily be right) is the largest, and since I frames is what brings the biggest effect to change of an occupation, in at least I frames, it is desirable to calculate these values for every GOP. In addition, in other examples, VBV_2 and VBV_drift may be calculated for every GOP in every other one, and may be calculated at other suitable spacing.
[0031] Overflow and forward VBV deviation drawing 3 show the deviation from VBV_1 of VBV_2 which have the inclination of overflow, and deviation of VBV_1 and VBV_2 is called for once for every GOP in I at the time of each initiation of GOP.
[0032] here -- or (VBV_2>Buffer_size-VBV_Thresh1) (VBV_drift>VBV_Thresh3) a case -- an encoder 6 -- setting -- I frames -- a stuffing bit (stuffing bits) is behind added to GOP, and VBV_2 are decreased. When there is an inclination of overflow, an encoder 6 generates GOP using all the conversion parameters saved. For example, VBV_2 are the occupation of the down-stream buffer 10. The occupation of the down-stream buffer 10 is in inverse proportion to the occupation of the buffer of an encoder 6. In an encoder 6, if a bit is added and an occupation is made to increase, the occupation in the down-stream buffer 10 will decrease.
[0033] Threshold Buffer_size-VBV_Thresh1 is shown in drawing 3 . If VBV_2 exceed a threshold, it will be easy to overflow a down-stream buffer.
[0034] Furthermore, the comparison of VBV_drift and VBV_Thresh3 is also shown in drawing 3 . Also when VBV_drift is greatly separated from VBV_1, it is easy to produce overflow in a down-stream buffer. Moreover, VBV_drift is supervised so that the difference of VBV_1 and VBV_2 may not become large. In order to reduce possibility that an underflow will occur in the future so that VBV_2 may decrease and VBV_1 may be approached and, the number of the stuffing bits added to GOP is chosen so that it may become a bigger value than VBV_1. a stuffing bit -- desirable -- the value of VBV_2 -- more -- the method of small ** -- it is -- VBV_2 -- or (Buffer_size-VBV_Thresh1) (VBV_1+VBV_Thresh3) is added until it becomes equal any they are.
[0035] An underflow and negative VBV deviation drawing 4 show the deviation from VBV_1 of VBV_2 which have the inclination of an underflow, and deviation of VBV_1 and VBV_2 is called for once for every GOP in I at the time of each initiation of GOP like an above-mentioned example. Furthermore, value Iframe_Offset is also used here. This value is good also as a fixed value showing the typical size of I frames defined beforehand. This value may be determined every I frames by measuring the size of I frames by replacing with this. By Iframe_Offset, in case I frames is decoded at the time of initiation of GOP, a bit can be removed from a down-stream buffer.
[0036] in order to reduce possibility that an underflow will arise, and negative VBV deviation -- every -- the rate of use of the conversion parameter saved is reduced so that possibility that will decrease the target number of bits for every GOP at the time of initiation of GOP, and deviation will become large, and an

underflow will arise may become high. That is, in order to reduce possibility that an underflow will arise, the target number of bits for every GOP is decreased. For example, the occupation of the down-stream buffer 10 is set to VBV_2. The occupation of the down-stream buffer 10 is in inverse proportion to the occupation of the buffer of an encoder 6. In an encoder 6, if the target number of bits is decreased, the occupation in the down-stream buffer 10 will increase.

[0037] this example -- setting -- or (VBV_2<VBV_Thresh1+Iframe_Offset) (VBV_drift< minus VBV_Thresh3) a case -- GOP -- the target number of bits is number[of some]-decreased, the conversion parameter saved about I and P frames is reused, and recoding of the B frames is carried out, without carrying out the reuse of the conversion parameter saved. These criteria show the small VBV deviation which can cause an underflow. With the number of some mentioned above, it considers as the value of VBV_drift, or the value in direct proportion to this value.

[0038] moreover -- or (VBV_2<VBV_Thresh2+Iframe_Offset) (VBV_drift< minus VBV_Thresh2) a case -- GOP -- frequency reduction of the target number of bits is carried out in the middle, the conversion parameter saved about I frames is reused, and recoding of B and the P frames is carried out, without carrying out the reuse of the conversion parameter saved. These criteria show VBV deviation of whenever [leading to an underflow / middle]. With frequency, the value of VBV_drift or the value in direct proportion to this value takes the middle in which it mentioned above.

[0039] moreover -- or (VBV_2<VBV_Thresh3+Iframe_Offset) (VBV_drift< minus VBV_Thresh1) a case -- GOP -- it decreases an extensive number and the target number of bits is not used for the conversion parameter saved at all, but recoding of all of I, P, and the B frames is carried out, without carrying out the reuse of the conversion parameter saved. These criteria show the large VBV deviation leading to an underflow. With the extensive number mentioned above, it considers as the value of VBV_drift, or the value in direct proportion to this value.

[0040] The amount to which the target number of bits (therefore, bit rate) is changed is chosen so that it may fall within the range which can permit the variation of a bit rate certainly.

[0041] (VBV_2<VBV_ThreshX+Iframe_Offset), and above-mentioned criteria have two conditions. [or (VBV_drift< minus VBV_ThreshY)] Based on the way that it is bad among these two conditions (big VBV deviation is shown), it determines preferably whether the target number of bits is decreased however and how many conversion parameters are reused.

[0042] Thereby, a conversion parameter can be reused as much as possible, and image quality can be maintained as much as possible.

[0043] In addition, it is shown that VBV_drift< minus VBV_ThreshY has a negative bigger value than VBV_ThreshY whose VBV_drift is a negative value. It will be |VBV_drift|>|VBV_ThreshY| if it expresses as an absolute value.

[0044] Example drawing 5 shown in drawing 5 and drawing 6 is drawing showing the configuration of the splicing equipment which applied this invention. The bit stream

A which is a long compression bit stream of GOP, and a bit stream B are inputted into the input terminals A and B of this splicing equipment. A bit stream B is decoded by baseband, a splice is carried out to the bit stream A decoded in the splice point Splice by the splicer shown as a change-over switch S1, thereby, the baseband bit stream C by which the splice was carried out is generated, and an encoder 6 re-encodes this baseband bit stream C. An encoder 6 is controlled by the controller 61. The conversion parameter saved from the decoded bit stream for the controller 61 is supplied.

[0045] As shown in drawing 6 , from the input terminal side of a decoder 21, through the delay machine DA, a bit stream A0 is supplied to the input terminal A of a change-over switch S2, and, thereby, is outputted from the output terminal S0 of this splicing equipment before time of day t0. The period before the splice time of day t2 and a decoder 21 decode a bit stream A0 from time of day t1 to baseband, and the input terminal A of a splicer S1 is supplied. On the other hand, a decoder 22 decodes a bit stream B0 to baseband, and supplies it to the input terminal B of a splicer S1. Before time of day t2, the signal with which the splicer S1 was supplied to the input terminal A is outputted from an output terminal C. Moreover, a splicer S1 outputs the signal supplied to the input terminal B from an output terminal C after time of day t2. The conversion parameter which is having the bit stream by which the splice was carried out saved from time of day t1 to the time of day t3 which is a transition period is not used for an encoder 6, or it re-encodes it only using a part. In this period, re-encoding is performed so that the transition to the VBV value of a bit stream B of a bit stream A from a VBV value may be controlled. Preferably, it carries out recoding using the I frame parameter saved, using as I frames the frame which were from the first. The technique of this recoding shall be indicated by the Europe patent application 00306699.No. (the surrogate number I-99-19, S00P5130, P/7372) 0 under continuation to coincidence, and this application shall be included in this application by reference. In time of day t3, VBV of a bit stream C is in agreement with VBV of a bit stream B. Recoding of a bit stream B is continued between time of day t3 and time of day t4. In time of day t4, a change-over switch S2 switches an input terminal C to an input terminal B, and, thereby, the compression bit stream B0 is outputted from the output terminal SO of this splicing equipment. In the period from time of day t3 to time of day t4, it operates, as the encoder 6 was explained using drawing 1 , drawing 3 , and drawing 4 based on this invention, and thereby, the deviation from the original bit stream B0 of the bit stream VBV value generated by the encoder 6 is reduced so that a VBV value may approximate as much as possible in time of day t4.

[0046] Example drawing 7 shown in drawing 7 and drawing 8 is the block diagram showing the configuration of the splicing equipment which applied this invention. The bit stream A which is a long compression bit stream of GOP, and a bit stream B are inputted into the input terminals A and B of this splicing equipment. a bit stream A is decoded by the decoder 21 -- having -- intra -- it is re-encoded with an encoder 141 by the compression bit stream which consists of I frames. a bit

stream B is decoded by the decoder 22 -- having -- intra -- it is re-encoded with an encoder 142 by the compression bit stream which consists of I frames. In the splice point Splice, the splice of the bit stream B of I frames is carried out to the bit stream A of I frames by the splicer shown as a change-over switch S1, and, thereby, the bit stream C of I frames by which the splice was carried out is generated. The bit stream C of I frames is re-encoded as a long compression bit stream of GOP by the I frame decoder 16 and the encoder 6. An encoder 6 is controlled by the controller 61. The conversion parameter saved from the decoded bit stream for the controller 61 is supplied.

[0047] a splicer 41 -- usually -- intra -- it is frame studio. bit streams AI and BI -- this intra -- it is recorded on the record medium of frame studio, and is read at the time of splicing processing. the bit stream CI by which splicing was carried out -- intra -- you may record on the record medium of frame studio. This record medium may be a tape-like record medium and/or a disk-like record medium.

[0048] as shown in drawing 8 , the period before the splice time of day t2 and a bit stream A0 are decoded by the decoder 21 from time of day t0 -- having -- intra -- by the frame encoder 141, if possible, at least, using the saved conversion parameter of I frames of the original bit stream A0, it will be re-encoded by I frames and the input terminal AI of a splicer S1 will be supplied. on the other hand, a bit stream B0 is decoded by the decoder 22 -- having -- intra -- by the frame encoder 142, if possible, at least, using the saved conversion parameter of I frames of the original bit stream B0, it will be re-encoded by I frames and the input terminal BI of a splicer S1 will be supplied. Before time of day t2, the signal with which the splicer S1 was supplied to the input terminal AI is outputted from an output terminal CI. Moreover, a splicer S1 outputs the signal supplied to the input terminal BI from an output terminal CI after time of day t2. The bit stream by which the splice was carried out [in / a decoder 16 and an encoder 6 operate between time of day t1 and the time of day t3 which is a transition period, and / this period] does not use the conversion parameter saved, or is re-encoded only using a part. Moreover, in this period, re-encoding is performed so that the transition to the VBV value of a bit stream B of a bit stream A from a VBV value may be controlled. Preferably, it carries out recoding using the I frame parameter saved, using as I frames the frame which were from the first. The technique of this recoding shall be indicated by the Europe patent application 00306699.No. (the surrogate number I-99-21, S00P5131, P/7374) 6 under continuation to coincidence, and this application shall be included in this application by reference. VBV of a bit stream C is in agreement with VBV of a bit stream B. Recoding of a bit stream B is preferably performed using all conversion parameters after time of day t3. When deviation arises in VBV after time of day t3, an encoder 6 is controlled by the controller 61, and based on this invention, as explained using drawing 2 , drawing 3 , and drawing 4 , it operates, and, thereby, the deviation from the original bit stream B0 of the bit stream VBV value generated by the encoder 6 is reduced.

[0049] in addition, the example shown in drawing 7 and drawing 8 -- setting -- a

bit stream A0 and a bit stream B0 -- time of day t1 -- previously -- as I frames -- decode -- and it is re-encoded. Here, when re-encoding reuses a coding parameter completely, this invention may be applied to encoders 141 and 142 before time of day t1.

[0050] The programmable digital signal processor controlled by the computer program may realize this invention. Therefore, the computer program product which realizes the technique which the processor performed and was mentioned above is also one gestalt of this invention.

[0051] As mentioned above, although this invention was explained based on MPEG 2 specification, this invention is applicable to other compression methods.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] It is the block diagram of the equipment which decodes a compression video data to baseband, processes the decoded video data, and re-encodes the processed video data.

[Drawing 2] It is the block diagram of the equipment which decodes a compression video data, carries out recoding as I frames, processes I frames, and re-encodes I processed frames.

[Drawing 3] It is drawing showing the control of overflow based on the down-stream occupation and down-stream this invention of a buffer of equipment which are shown in drawing 1 , drawing 2 , drawing 5 , or drawing 7 .

[Drawing 4] It is drawing showing control of the underflow based on the down-stream occupation and down-stream this invention of a buffer of equipment which are shown in drawing 1 , drawing 2 , drawing 5 , or drawing 7 .

[Drawing 5] It is the block diagram of the equipment which decodes a compression video data to baseband, edits the decoded video data, and re-encodes the edited video data.

[Drawing 6] It is a timing chart explaining actuation of the equipment shown in drawing 5 .

[Drawing 7] It is the block diagram of the equipment which decodes a compression video data, carries out recoding as I frames, edits I frames, and re-encodes I edited frames.

[Drawing 8] It is a timing chart explaining actuation of the equipment shown in drawing 7 .